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JUNE 2025 TO APRIL 2026

MAINS 365

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OPTIONAL SUBJECT CLASSES 2027

- Anthropology
- Geography
- Physics
- Sociology
- Public Administration
- Political Science and International Relations
- History
- Philosophy

Starts : **1 JULY**

ENVIRONMENT

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Preface

To the Aspirant Who Dares to Dream

In the quiet corners of libraries across India, in the solitude of late-night study sessions, and in the hearts of millions who dare to dream of serving the nation, lies an unwavering determination to crack one of the world's most challenging examinations – the UPSC Civil Services Examination.

Mains 365 was born from that very spirit of determination and the recognition that success in UPSC CSE Mains 2026 demands more than just hard work; it requires strategic preparation, comprehensive understanding, and the ability to connect diverse streams of knowledge into coherent, impactful answers.

Q.1 Why most of the aspirants fail to crack mains?

- ◆ Scattered Information: Jumping between multiple sources creates confusion
- ◆ Outdated Content: Using materials that don't reflect current developments
- ◆ Lack of Integration: Inability to connect static knowledge with current affairs
- ◆ Poor Answer Structure: Not knowing how to present knowledge effectively
- ◆ Missing the UPSC Mindset: Failing to understand what UPSC actually want

But what if you could overcome ALL these challenges with ONE comprehensive resource?

Q2. Why Mains 365 Environment?

It is a one-stop annual compendium that distils every high-stakes current-affairs theme—Climate Change Conferences, Recent Disasters, Alternative Energy Resources—into exam-ready notes mapped topic-by-topic to the UPSC CSE Mains syllabus.

Also, Environment Mains 365 document enriches multiple GS papers—e.g., Environment links with GS-I (Geophysical Phenomena), GS-II (Climate Policy), and GS-IV (Environmental Ethics).

Q3. How does it mirror the General Studies papers?

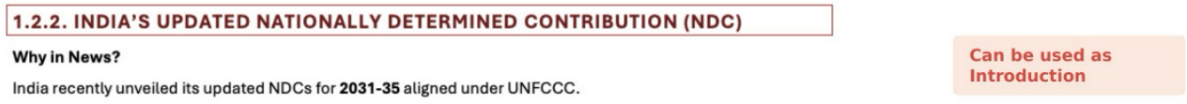
Chapters are mapped after syllabus topics and recurring themes in the UPSC exam like Climate Change, Environmental Pollution and Degradation, Disaster Management, Conservation Efforts, etc., so you can easily match your reading with the syllabus and PYQ checklist.

Q4. I already have static books. Why do I need this?

Static concepts fetch marks only when linked to real examples. Mains 365 does this by connecting the year’s key trends, data, committee reports, examples, etc. making your answers sharper, richer, and more analytical.

Q5. Will it actually save me time in the exam hall?

Yes. Infographics, Definition, Targets and “Why in News” blocks act like visual flashcards; you recall a picture, not a paragraph. That shaves minutes off every 10- or 15-marker.

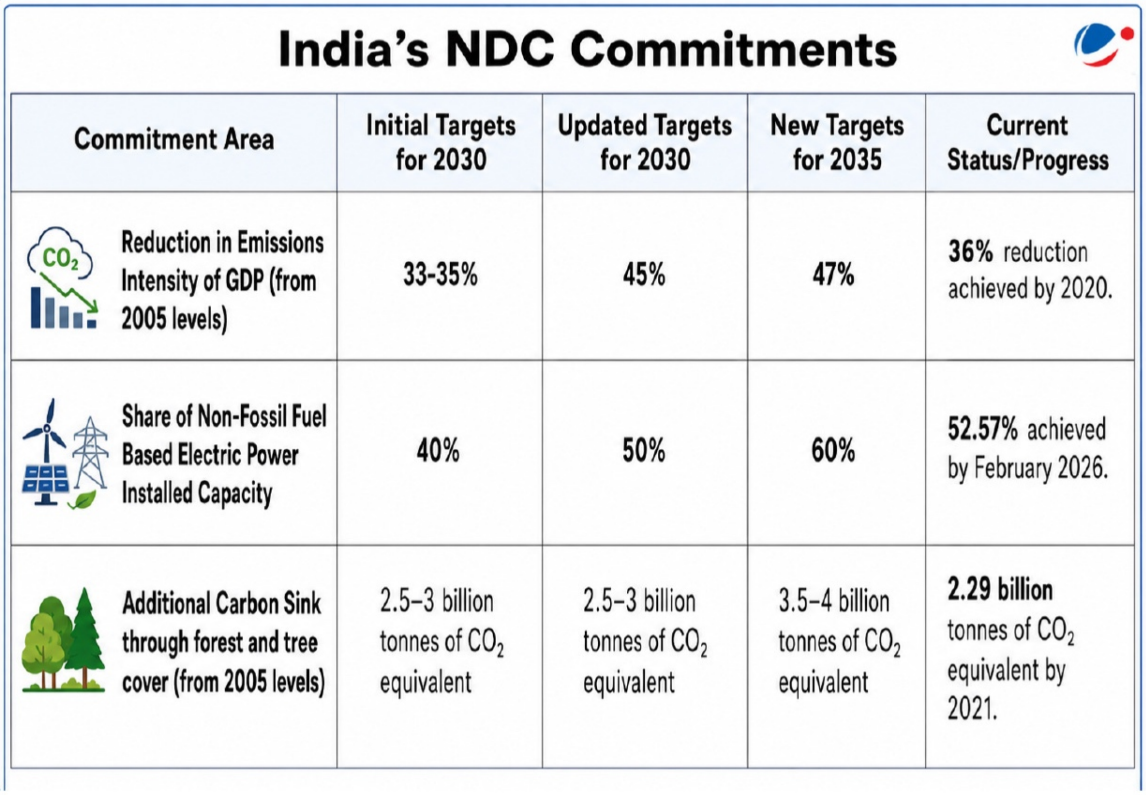


1.2.2. INDIA’S UPDATED NATIONALLY DETERMINED CONTRIBUTION (NDC)

Why in News?

India recently unveiled its updated NDCs for **2031-35** aligned under UNFCCC.

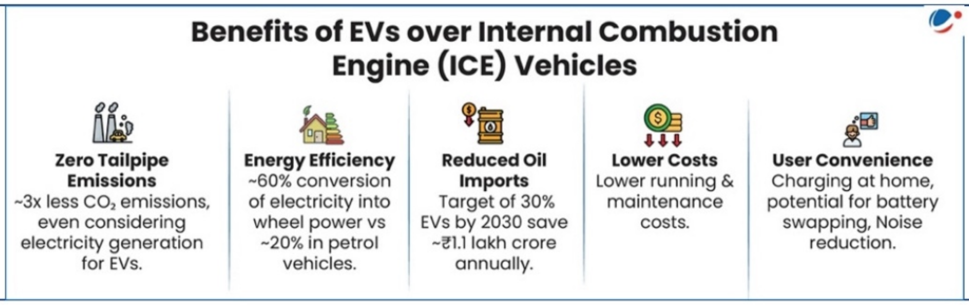
Can be used as Introduction



India's NDC Commitments

Commitment Area	Initial Targets for 2030	Updated Targets for 2030	New Targets for 2035	Current Status/Progress
Reduction in Emissions Intensity of GDP (from 2005 levels)	33-35%	45%	47%	**36%** reduction achieved by 2020.
Share of Non-Fossil Fuel Based Electric Power Installed Capacity	40%	50%	60%	**52.57%** achieved by February 2026.
Additional Carbon Sink through forest and tree cover (from 2005 levels)	2.5–3 billion tonnes of CO_2 equivalent	2.5–3 billion tonnes of CO_2 equivalent	3.5–4 billion tonnes of CO_2 equivalent	**2.29 billion** tonnes of CO_2 equivalent by 2021.

Clearly and crisply mentions India's Targets and its progress, also tabular representation aids visual memory.



Benefits of EVs over Internal Combustion Engine (ICE) Vehicles

Zero Tailpipe Emissions
~3x less CO_2 emissions, even considering electricity generation for EVs.

Energy Efficiency
~60% conversion of electricity into wheel power vs ~20% in petrol vehicles.

Reduced Oil Imports
Target of 30% EVs by 2030 save ~₹1.1 lakh crore annually.

Lower Costs
Lower running & maintenance costs.

User Convenience
Charging at home, potential for battery swapping, Noise reduction.

Suitable Infographics not only serve as Value addition but can be imitated in exam.

Q6. What gives my answers extra credibility?

Ready-to-use definitions, latest data from recent reports (e.g., National Compilation on Dynamic Ground Water Resources of India 2025) and recommendations from official sources (e.g., NDMA Guidelines), key words plus facts (e.g. Baku to Belem roadmap aims to mobilize New Collective Quantified Goal (NCQG) of $1.3 trillion/year by 2035) embed instant authority. UPSC love precise references.

Q7. How is it structured for the 3-hour examination?

Every sub-topic follows the golden sequence—Context → Analysis → Way Forward—so you can lift the framework, plug in your insights, and write at full speed while others are still outlining.

Q8. Can you demonstrate an actual question?

PYQ: "What is Carbon Capture, Utilization and Storage (CCUS)? What is the potential role of CCUS in tackling climate change? (GS-III 2025, 10 Marks)"

Quick extract from Mains 365 →

- Definition of CCUS (Can also briefly mention about the processes involved)
- Significance of CCUS (Includes Key points in its role in tackling climate change)
- Way Forward (Ways for its implementation or highlighting India's initiative towards it)

Plug these into Intro-Body-Conclusion:

Start by defining CCUS, mention the processes involved, list out the role of CCUS in tackling climate change and conclude by suggesting viable ways for its implementation.

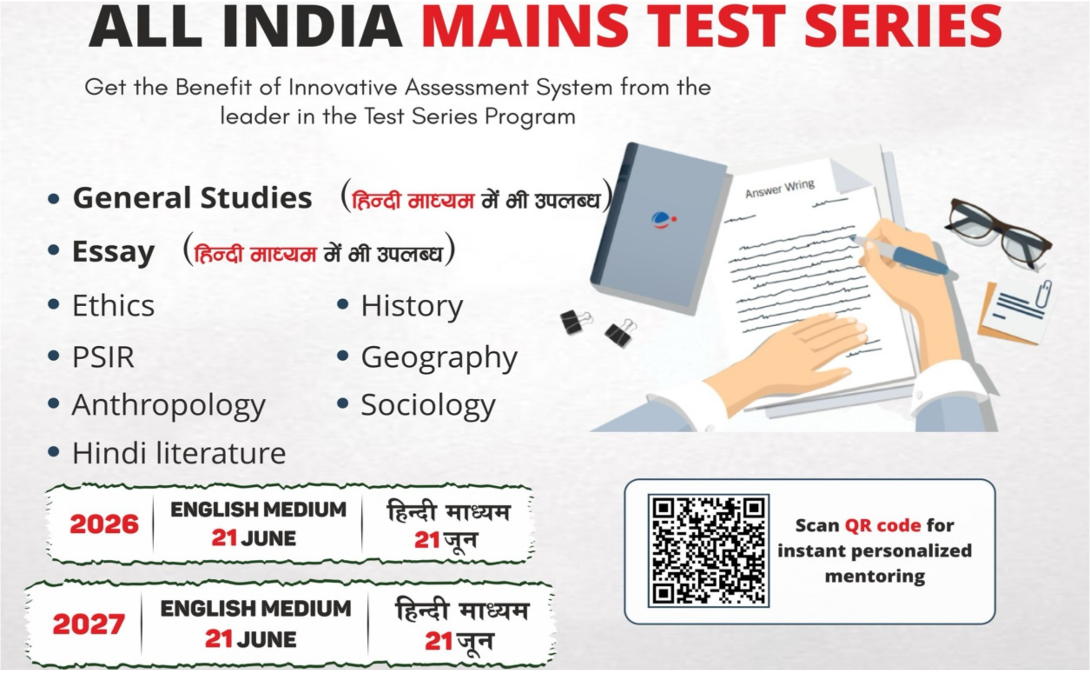
Result will be a focused, 150-word answer that links recent examples and standard guidelines to theory—just what UPSC looks for in a 10-mark question.

Q9. What's the recommended micro-structure for each 15-marker?

Intro (≤ 30 sec):	Body (≤ 6 min):	Way forward (≤ 1 min):	Conclusion (1 line):
Why in the News, or data/facts.	2–3 dimensions, each with evidence & analysis.	3–4 actionable reforms.	Memorable, visionary sentence.

Q10. Any final pro tip?

Think of Mains 365 as a ready answer bank: it's pre-curated—your job is just to pick, organise, and add your own insight. Use it wisely and find questions becoming easier to answer and higher marks becoming more achievable.



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2027	ENGLISH MEDIUM 21 JUNE	हिन्दी माध्यम 21 जून

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1. CLIMATE CHANGE

1.1. UNFCCC COP30

Why in News?

Recently, 30th Conference of Parties (COP30) to United Nations Framework Convention on Climate Change (UNFCCC) was held in Belém, Brazil which also coincided with 10th anniversary of Paris Agreement.

More on News

- Summit was framed as **"COP of Implementation", "COP of Truth",** and "**Forest COP".**
- COP30 **aligned** with deadline for countries to submit **updated** Nationally Determined Contributions **(NDC 3.0)** in **2025**.
- It concluded with adoption of **Belem Package**, by **195 Parties**.

Outcome	Details
Belém Mission to 1.5°C	• **Purpose: action-oriented platform** under COP29-COP31 troika. • **Launched by/Under: COP29-COP31 Troika [Azerbaijan (COP29), Brazil (COP30), and Türkiye (COP31)]**
Tropical Forest Forever Facility (TFFF)	• **Purpose:** Establish a $125B **Tropical Forest Investment Fund (TFIF)** (atleast 20% payment to **Indigenous Peoples and Local Communities)** • **Launched by/Under:** Brazil, Indonesia, DRC, China etc. **(India as an Observer).** Trustee and Interim host: **World Bank**
Baku to Belém Roadmap to 1.3T	• **Purpose:** Official pathway to **mobilize New Collective Quantified Goal (NCQG**) of **$1.3 trillion/year by 2035.** • **Launched by/Under:** COP 29 & 30 Presidencies
Tripling of adaptation finance	• **Purpose:** Increase adaptation finance to **$120 billion per year**, part of broader $300 billion/year in climate finance (known as **New Collective Quantified Goal (NCQG)**, agreed at COP29).
Baku Adaptation Roadmap	• **Purpose:** Approves/establish work for 2026-2028, until next Global Stock take of Paris Agreement.
Belém 4x Pledge on Sustainable Fuels	• **Purpose: Quadruple use of sustainable fuels** (hydrogen, biofuels, e-fuels) by 2035 compared to 2024 levels. • **Launched by: Italy, Japan, India, Brazil** etc. **International Energy Agency (IEA)** to track progress**.**
Belém Health Action Plan	• **Purpose: World's first climate adaptation plan** dedicated to health. **$300 million in initial funding** mainly for Global South. • **Launched by:** >30 countries & 50 organizations.
Other Initiatives	• Declaration on Information Integrity on Climate Change • Call to Action on Integrated Fire Management and Wildfire Resilience • Plan to Accelerate Coal Transitions (PACT) • National Adaptation Plans (NAPs) Implementation Alliance • Scaling J-REDD+ (Jurisdictional Reducing Emissions from Deforestation and forest Degradation+) • Belém Gender Action Plan (GAP) • FINI (Fostering Investible National Implementation) • Global Implementation Accelerator • Resilient Agriculture Investment for net-Zero land degradation (RAIZ) Accelerator

Significance of COP30

- Shifted **global climate governance** from **pledge-making to implementation and accountability.**

- Global push for **adaptation finance** addressing **long-standing Global South concerns.**
- Scalable global model for forest conservation **not tied to carbon markets through TFFF.**
- **USD 1.3 trillion/year goal** represents most ambitious climate finance mobilisation target.
- All 195 parties adopted Belém Package, showing **multilateral resilience.**

Way Forward

- **NDC 3.0** should include economy-wide absolute emission reduction targets; Policies to make enabling conditions to **make target credible.**
- **Finalize GGA** (Global Goal on Adaptation) **indicators**; clear mandate needed for **Global Implementation Accelerator (GIA)** and **Belem 1.5 Mission.**
- **CBDR (Common but Differentiated Responsibilities) should guide mitigation** timelines and finance flows; resolve tensions through international platforms; etc.
- Governments need to **build on private sector pledges** (e.g., from **TFFF** or **Ocean Breakthroughs**) by **creating enabling environments:** clear regulations, incentives, etc.
- **Public engagement** (as seen in **Belém Climate March**) **needs institutional pathways**.

Conclusion

COP30 signalled a shift toward **operationalising Paris Agreement** by expanding adaptation finance, and **institutionalising forest conservation** with **Belém Package** signalling a shift toward **implementation and inclusion.**

1.1.1. OTHER IMPORTANT OUTCOMES OF COP30

Initiative/Coalition/Outcome	Details
Systematic Observation Impact Bond	• **World's first** impact bond on weather and climate data. • Announced as part of **COP30 (UNFCCC) Action Agenda.** • **Aim**: Seeks initial capitalization of **USD 200 million by end of 2026.** • **Significance**: Help 30 Least Developed Countries (LDCs) and Small Island Developing States (SIDS) meet Global Basic Observing Network (GBON) standards. • **Launched by**: **Systematic Observations Financing Facility (SOFF),** a United Nations fund created by UNEP, WMO and UNDP
Global Mutirão Against Extreme Heat / Beat the Heat Implementation Drive	• **Aim:** Reduce heat risks for **3.5 billion people** globally and integrate solutions into **50 national adaptation frameworks** by 2030. • 72 nations endorsed **Global Cooling Pledge** (reduce cooling-related emissions by 68% by 2050). • **COP30 Presidency** and **UNEP-led Cool Coalition.**
Food Waste Breakthrough	• Launched as 2030 Climate Solution under **Marrakech Partnership for Global Climate Action.** • **Target: Halving global food waste** and up **to 7% reduction in methane emissions by 2030.** • **Funding Support: Global Environment Facility** commits US$3 million. • **Participation: Brazil, Japan,** UK **as country champion (Led by UNEP).**
Oceans Breakthroughs Dashboard	• Track progress within 5 ocean sectors (marine conservation, renewable energy, shipping, aquatic food, and coastal tourism) • **cut emissions by up to 35% by 2050**
Utilities for Net Zero Alliance (UNEZA)	• Raised annual investment targets to **USD 148billion at COP30.** • Members collectively aim to invest ~**USD 1 trillion by 2030**. • Established at **COP28** with adoption of **UAE Declaration of Action**
Others	• **Plan to Accelerate Solution (PAS) on Multilevel Governance.** • **Climate and Health Funders Coalition (CHFC)**

	- **Global Network of Regenerative Seascapes** (for regenerative blue economy). - **No Organic Waste (NOW),** cutting 30% methane emissions from organic waste by 2030.

1.2. INDIA AND CLIMATE ACTION

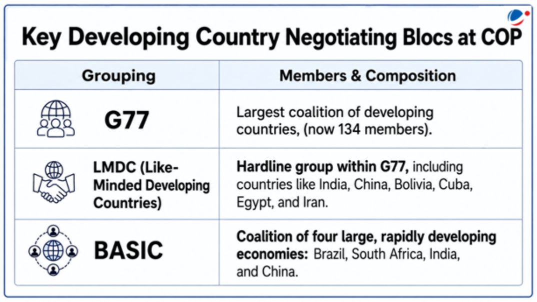
1.2.1. INDIA'S POSITION AT COP30

Why in News?

India's negotiating posture at **COP30** focused on **implementation** and operationalizing **climate justice**.

Core Objectives

India's strategy, delivered across the G77+China, **BASIC**, and **LMDC** groupings, rested on these **non-negotiable principles**:



Key Developing Country Negotiating Blocs at COP

Grouping	Members & Composition
G77	Largest coalition of developing countries, (now 134 members).
LMDC (Like-Minded Developing Countries)	**Hardline group within G77,** including countries like India, China, Bolivia, Cuba, Egypt, and Iran.
BASIC	**Coalition of four large, rapidly developing economies:** Brazil, South Africa, India, and China.

India's Position at COP 30

Key Area	India's Stance and Statements
Equity and Climate Justice	- Reiterated **Equity and "Common but Differentiated Responsibilities" (CBDR-RC)** as cornerstone of global climate regime. - Burden of mitigation to not shift to those with **"least responsibility in causing problem"**.
Climate Finance: Legal Obligation	- Implementation of **Article 9.1** is a legal obligation for developed countries. - Finance being **"key barrier to raised ambition."** - Requested a clear, universally agreed definition of climate finance
Adaptation and Global Goal	- Declared that COP 30 must be the **"CoP of Adaptation".** - Welcomed progress on **Global Goal on Adaptation (GGA)**.
Just Transition Mechanism	- Welcomed **Just Transition Mechanism** to operationalize equity. - Transition work programs to result in people centric **"action-oriented institutional arrangements."**
Mitigation and Net Zero Responsibilities	- Developed countries must **"reach net-zero earlier"** to preserve equitable carbon space. - Developed nations to invest more in **negative emissions technologies**.
Unilateral Trade	- Rejected **"Unilateral Trade-restrictive Climate Measures"** for being protectionist.
Technology Transfer and Access	- **Technology Access is a Right, not a Bargaining Tool**. - **Intellectual property & market barriers** to not hinder technology transfer to developing nations.
Multilateralism and Diplomacy	- Unwavering support for **multilateralism**. - Praised Brazilian Presidency rooted in **" Mutirão"** (inclusion and balance).

Conclusion

India's response called on all Parties to put in **collective effort** to ensure that road from Belém leads to a future **defined by fairness, solidarity, and shared prosperity for all.**

1.2.2. INDIA'S UPDATED NATIONALLY DETERMINED CONTRIBUTION (NDC)

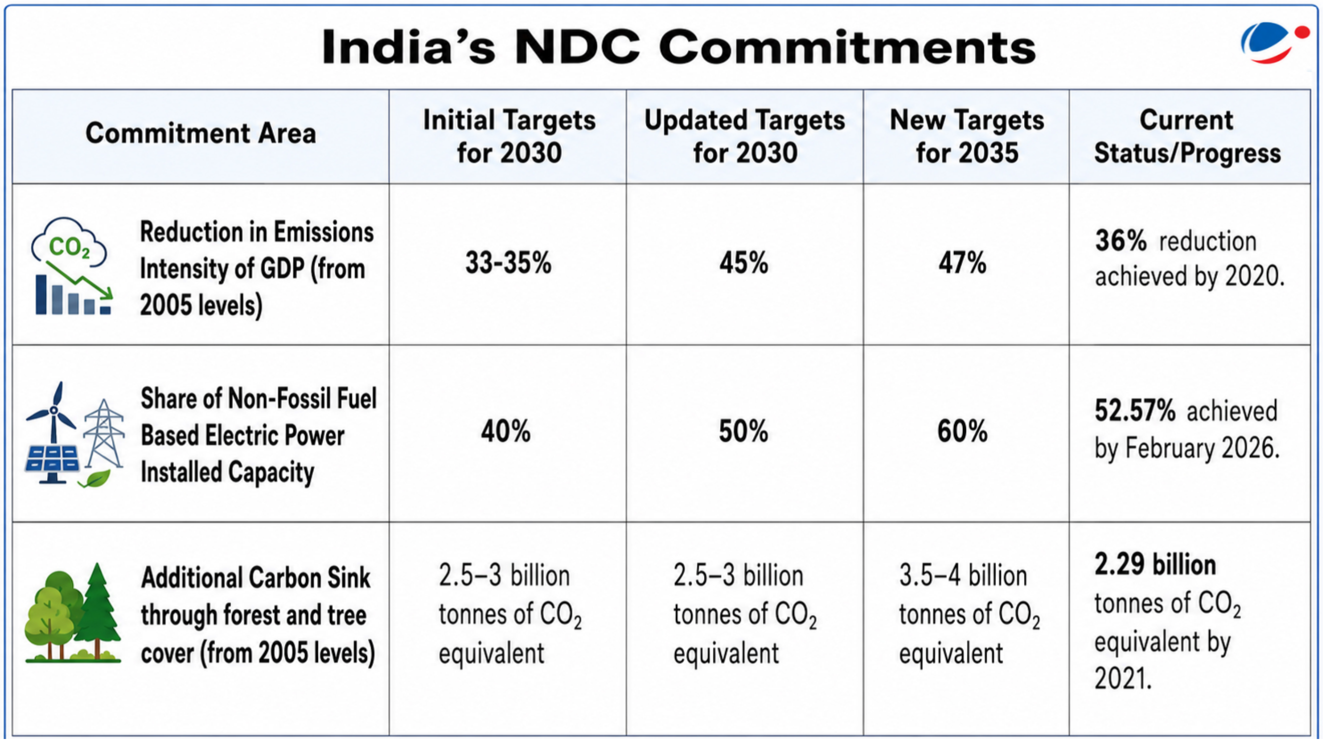
Why in News?

India recently unveiled its updated NDCs for **2031-35** aligned under UNFCCC.

MAINS 365 – ENVIRONMENT

About Nationally Determined Contributions (NDCs)

- **Voluntary, country-specific climate action plans** under Paris Agreement aimed at **reducing greenhouse gas emissions** and **adapting to climate change**.
- NDCs are **submitted every five years** to UNFCCC secretariat.
  - **India submitted its first NDC in 2015**, updated it in 2022.
- **Considerations for India's NDC for 2031-2035**:
  - Vision for 'VIKSIT BHARAT @2047'
  - Commitment to sustainable growth, while following low-carbon strategies
  - India's minimal historical contribution towards global warming and its unique developmental needs and special national circumstances
    - During 2005-2019, India's economy expanded at 7% CAGR, while emissions increased at ~4%
  - Need for fair, equitable and just sharing of global carbon budget



India's NDC Commitments

Commitment Area	Initial Targets for 2030	Updated Targets for 2030	New Targets for 2035	Current Status/Progress
Reduction in Emissions Intensity of GDP (from 2005 levels)	33-35%	45%	47%	**36%** reduction achieved by 2020.
Share of Non-Fossil Fuel Based Electric Power Installed Capacity	40%	50%	60%	**52.57%** achieved by February 2026.
Additional Carbon Sink through forest and tree cover (from 2005 levels)	2.5–3 billion tonnes of CO_2 equivalent	2.5–3 billion tonnes of CO_2 equivalent	3.5–4 billion tonnes of CO_2 equivalent	**2.29 billion** tonnes of CO_2 equivalent by 2021.

Measures Taken Towards Achieving the NDCs

- **Clean Energy:** National Green Hydrogen Mission; PM Surya Ghar Muft Bijli Yojana; PM-KUSUM; PLI schemes for High Efficiency Solar PV Modules etc.
- **Forging international partnerships:** International Solar Alliance (ISA), Coalition for Disaster Resilient Infrastructure (CDRI); Global Bio-fuel Alliance (GBA); etc.
- **Industrial Emission reduction:** Carbon Credit Trading Scheme (CCTS) [2023] under **Energy Conservation Act, 2001,** laid the foundation for **Indian Carbon Market (ICM)**.
  - **Greenhouse Gases Emission Intensity Target Rules**, under CCTS.
- **Climate Adaptation: National Action Plan on Climate Change** (NAPCC); State Action Plans (SAPCC); **National Mission on Sustainable Agriculture**; **Jal Jeevan Mission**, etc.
- **Expanding Carbon Sink:** Green India Mission; Nagar Van Yojana (NVY); National Fund of Compensatory Afforestation Fund Management and Planning Authority (CAMPA); etc.
- **Energy Efficiency:** UJALA (Unnat Jyoti by Affordable LEDs for All) scheme, Street Lighting National Programme, BEE's Star Labelling Programme; etc.
- **Other measures:** Push for Carbon Capture, Utilization and Storage (CCUS) and nuclear energy; Mission Lifestyle for Environment (LiFE); PAT scheme; etc.

Challenges for India in Achieving NDCs

- **Financial and Technical Constraints:** Total investment required for energy transition is estimated at **~USD 250 billion per year till 2047** (NITI Aayog).
- **Gap between Capacity and Generation:** While non-fossil fuel sources account for 50% of Installed power capacity, contribute less than 30% to actual electricity generated.
- **Storage and Grid Related Challenges:** High cost of large-scale battery storage, reliance on imported critical minerals (like lithium).
- **Heavy Dependence on Coal:** Still accounting for **around 55% of India's electricity generation.**
- **Others:** Land scarcity (Solar can need 300 times as much space as nuclear), solar battery materials require substantial water extraction and carbon emissions, etc.

Way Forward

- **Mobilizing Climate Finance** through **CBDR-RC** principle, actively leveraging tools like green bonds, blended finance etc.
- **Renewable Energy Investments** in Grid infrastructure, energy storage technologies, and green hydrogen development.
- **Bridging Capacity-Generation Gap by** promoting hybrid systems integrating solar, wind, and storage.
- **Enhancing Carbon Sink** through Agroforestry, urban forestry, and conservation projects by local communities.

Conclusion

Renewable energy acceleration, carbon sinks, and adaptation investments will help deliver **Viksit Bharat 2047** in prosperous and climate-resilient manner.

1.3. CLIMATE CHANGE IMPACTS

1.3.1. GLACIER PRESERVATION

Why in the News?

India reaffirmed Commitment to Glacier Preservation at High-Level International Conference on Glaciers' Preservation in **Dushanbe (Tajikistan**) in collaboration with **UNESCO and World Meteorological Organisation (WMO)**.

Glaciers and Glacier loss

- Glacier is a large, perennial **accumulation of snow and ice that slowly flows over land** under the influence of its own weight and gravity.
    - Typically, glaciers exist in areas where **mean annual temperatures are close to freezing point** and **winter precipitation** produces significant accumulations of **snow**.
- **Signs of accelerated melting and Glacier loss:**
    - **Melting rate doubled** since 2000 with Ganga and Brahmaputra basins witnessing alarming reductions of 21% and 16% respectively. (ICIMOD)
    - **Dead glaciers**: Yala Glacier, Nepal (2025); Ayoloco glacier, Mexico (2021); Clark Glacier, US (2020); Okjokull glacier, Iceland (2019); Pizol Glacier, Switzerland (2019); etc.

Significance of Glacier Preservation

Water Reservoir	Natural archives of Earth's climate	Climate regulation
• Only **3% of Earth's water** is fresh, and **two-thirds** is frozen in glaciers. • **Contributes to River Ecosystem,** e.g. Hindu Kush Himalayas (HKH) a.k.a. Third Pole contributes ~ **40%** of Indus River system's flow.	Stores records up to **800,000 years,** to understand **warming & cooling cycles.**	Temperature difference between Himalayan glaciers & Indian Ocean **pulls South West monsoon.**

Factors Responsible for Increased Glacier Melting

- **Global Warming & Climate Change** with more warming in Higher altitudes (4,500–6,000 meters).
- **Black Carbon and Surface Debris** (absorbs heat and induces glacial melt)
- Decline in **seasonal snow weakens** natural insulation.
- **Erratic Weather Systems like** erratic Western Disturbances.
- **Steep longitudinal gradients** causing high-velocity, destructive debris surges.

Effects of Deglaciation

- **Climate Feedback Loop:** Melting glaciers **reduce Earth's reflectivity (albedo),** absorbing more heat & accelerating global warming.
    - **Highest on record Arctic Surface Air Temperatures** during past year (Oct 2024-Sept 2025) since 1900. (**Arctic Report Card (ARC) 2025)**
    - Phenomena of **Atlantification; rusting of rivers; and greening of Arctic** witnessed.
- **Accelerates sea level rise:** Glacier mass loss between 2000 and 2023 was equivalent to a~0.75 mm per year of global sea-level rise. (WMO)
- **Cascading Disasters:** Glacial Lake Outburst Floods (GLOFs); Permafrost thaw, landslides, debris flows, E.g., Chamoli 2021, Sikkim 2023, Dharali 2025.
- **Others:** Water Insecurity (reduced river flows, altered hydrology); Agricultural Disruption etc.

Initiatives Taken

India

- **National Mission for Sustaining the Himalayan Ecosystem (NMSHE):** Under **India's National Action Plan on Climate Change (NAPCC).**
- **Research: Centre for Cryosphere and Climate Change Studies** for monitoring of glaciers in Indian Himalayan Region; Himansh Research Station studies the dynamics and the rate of change of Himalayan glaciers; Missions to Arctic & Antarctic e.g., IndARC (2014) etc.

- **Disaster preparedness**: Glacial Lake Outburst Flood (GLOF) risk mapping; National GLOF Risk Mitigation Programme (NGRMP); **etc.**

Global

- Declared **2025 as International Year of Glaciers Preservation (by UNESCO and WMO) & Decade (2025–2034) of Action for Cryosphere Sciences.**
- **International Centre for Integrated Mountain Development (ICIMOD)**: Intergovernmental institution to preserve **HKH.**
- **Others:** Global Glacier Casualty List (GGCL) project; UNESCO Intergovernmental Hydrological Programme; Himalayan Adaptation Network by IUCN; Living Himalayas Initiative by World Wide Fund for Nature.

Way Forward

- **Strengthening Institutional Framework:** Ministry of Jal Shakti (MoJS) and Central Water Commission (CWC) as nodal agencies.
- **Disaster Preparedness:** Satellite based early warning (like Sentinel-2); Community centric monitoring; bio restoration; Structural mitigation (e.g. Geo-Engineering).
- **Polar Research Efforts:** E.g., **Maitri II,** India's new research station in Eastern Antarctica to promote research.

Conclusion

Retreat of glaciers represents **not only warning but immediate reality** with far-reaching implications hence requiring **enhanced global cooperation, shared scientific research,** etc.

1.3.2. HEALTH AND CLIMATE CHANGE

Why in the news?

Belem Action Plan for Health and Climate Adaptation launched at **COP30 in Belem, Brazil** is the first international climate adaptation document focused specifically on health.

Key Highlights

- **Aim: strengthening global health systems** to cope better with impacts of climate change.
- Structured around two **cross cutting principles and concepts** - **health equity** and '**climate justice**' and leadership and governance on climate and health with social participation.
- **Funding:** About 35 philanthropies, under banner of **Climate and Health Funders Coalition**, announced an initial commitment of **US $300 million** for implementation.

Need for Climate Health Adaptation Plan

- **Extreme heat**: Over 540 000 people dying from extreme heat each year.
- **Vulnerable population: 3.3 to 3.6 billion people already live in areas highly vulnerable to climate change.**
- **Threat to infrastructure**: 1 in 12 hospitals worldwide at risk of climate-related shutdowns and Hospitals are facing 41% higher risk of damage from extreme weather.

Way forward: 3 lines of action outlined under Belem Action Plan for Health and Climate Adaptation

- **Surveillance & Monitoring:** Climate-informed early warning systems and integrated data platforms.
- **Evidence-based Policy & Capacity Building:** Workforce upskilling, gender-responsive and equity-driven health policies, integration of mental health and psychosocial support etc.
- **Innovation & Production:** Resilient infrastructure, **just transitions**, sustainable supply chains, and return-on-investment frameworks.

Conclusion

Understanding of climate and health challenges requires identifying core climate and health process, and initiating public and private sector engagement in designing and delivering **climate resilient healthcare.**

1.3.3. CLIMATE CHANGE AND POVERTY

Why in the News?

NISER study finds that climate shocks are increasingly intensifying poverty in India.

Relationship between Climate Change and Poverty

- **Climate Induced Economic Stress:**
  - **Recurring floods:** Damage crops, infrastructure, and homes, pushing vulnerable populations into cycles of loss and recovery.
  - **Drought Trap:** Agriculture dependent drought prone regions face higher poverty due to **crop failures and debt cycles.**
- **Economic diversification:** Service-oriented economies are less directly exposed to weather disruptions.
  - 1 unit increase of service sector in its GSDP **lowers poverty probability by ~1.9%.**
- **Tribal Vulnerability:** More vulnerable to climate shocks, due to dependence on natural resources, and show a greater likelihood of poverty.

Way Forward

- **Region-Specific Policies:** Beyond one size fits all to **district-level targeted strategies** based on local vulnerabilities.
- **Strengthen Implementation**: Improve execution of **National Action Plan on Climate Change (NAPCC), State Action Plans (SAPCC)** and SDG India Index.
- **Climate Resilient Agriculture:** Promote drought-resistant crops, efficient irrigation systems etc.
- **Others:** Expanding non-farm employments, Integrated policymaking, investments in disaster resilient infrastructures etc.

Conclusion

Governments should take action to **reduce the burden of policies** that impose new costs by **strengthening social protection and assistance** to help the vulnerable.

1.3.4. CLIMATE CHANGE AND OCEANS

Why in the News?

Recently, third **United Nations Ocean Conference (UNOC3)** concluded in France (co-hosted by France and Costa Rica) with adoption of **Nice Ocean Action Plan**.

Key Highlights of Action Plan

- **Global roadmap for SDG 14 Achievement:** Declaration recognized that SDG 14 (conserve and sustainably use oceans, seas, and marine resources) is least funded of all SDGs.
- **Plastic Pollution:** Reaffirms commitment to develop international legally binding instrument.
- **Coordinated global action: Climate and acidification** impacts on oceans and coastal communities.

Impact of climate change on Oceans

- Oceans absorbed additional **23 zettajoules of heat (2025),** highest ever recorded since 1960s.
  - **Oceans capture about 90% of excess heat** generated by greenhouse gas emissions.
- Global average **Sea Surface Temperatures (SSTs) in 2025 were among highest ever recorded (approximately 0.5°C above the 1981–2010 average).**
- **Ocean acidification** breached planetary boundary.

- **Ocean acidification** refers to a reduction in the **pH of the ocean over an extended period of time,** caused primarily by **uptake CO_2** from the atmosphere.

Major Implications of Ocean Warming and acidification

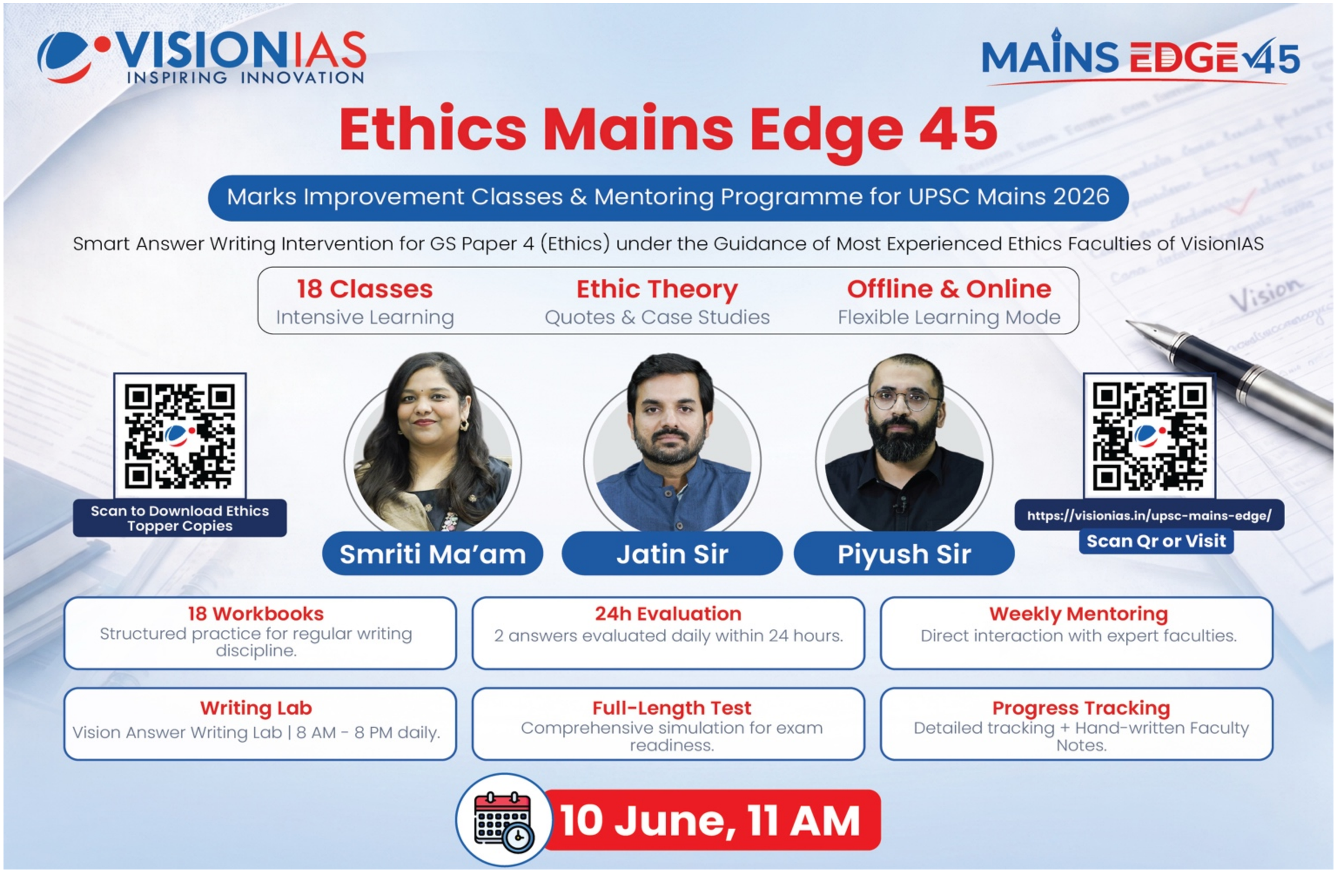
- **Increased Ocean stratification:** Warmer surface waters reduce mixing of water layers**,** causing **lower oxygen supply** to deeper waters**, reduced nutrient transport to surface.**
- **Increase in Marine Heat Waves:** Cause **coral bleaching, migration and breeding changes of marine species etc.**
- **Impact of weather:** Warmer oceans **can lead to more intense cyclones and hurricanes;** Ocean acidification can indirectly affect cloud formation
- **Threat to Marine Ecosystems:** Acidic waters lead to **dissolution of calcium carbonate structures** (affecting organisms like corals, shellfish, and plankton) and **Ecosystem alterations**.

Initiatives to Protect Ocean Ecosystem

- **Marine Protected Areas (MPAs):** Regions designated for conservation, restricting activities to protect marine life.
- **UN Decade of Ocean Science for Sustainable Development (2021-2030)**
- **Indian Initiatives:** MISHTI (Mangrove Initiatives for Shoreline Habitats & Tangible Incomes, etc.), Deep Ocean Mission, etc.
- **Blue National Determined Contributions (NDC) Challenge:** Launched by France and Brazil aiming to place ocean at the heart of NDCs ahead of COP30.

Conclusion

Protecting oceans is essential for climate stability, biodiversity conservation, and sustainable development. **Strengthened global action and effective conservation measures** are crucial to securing a healthy and resilient ocean for future generations.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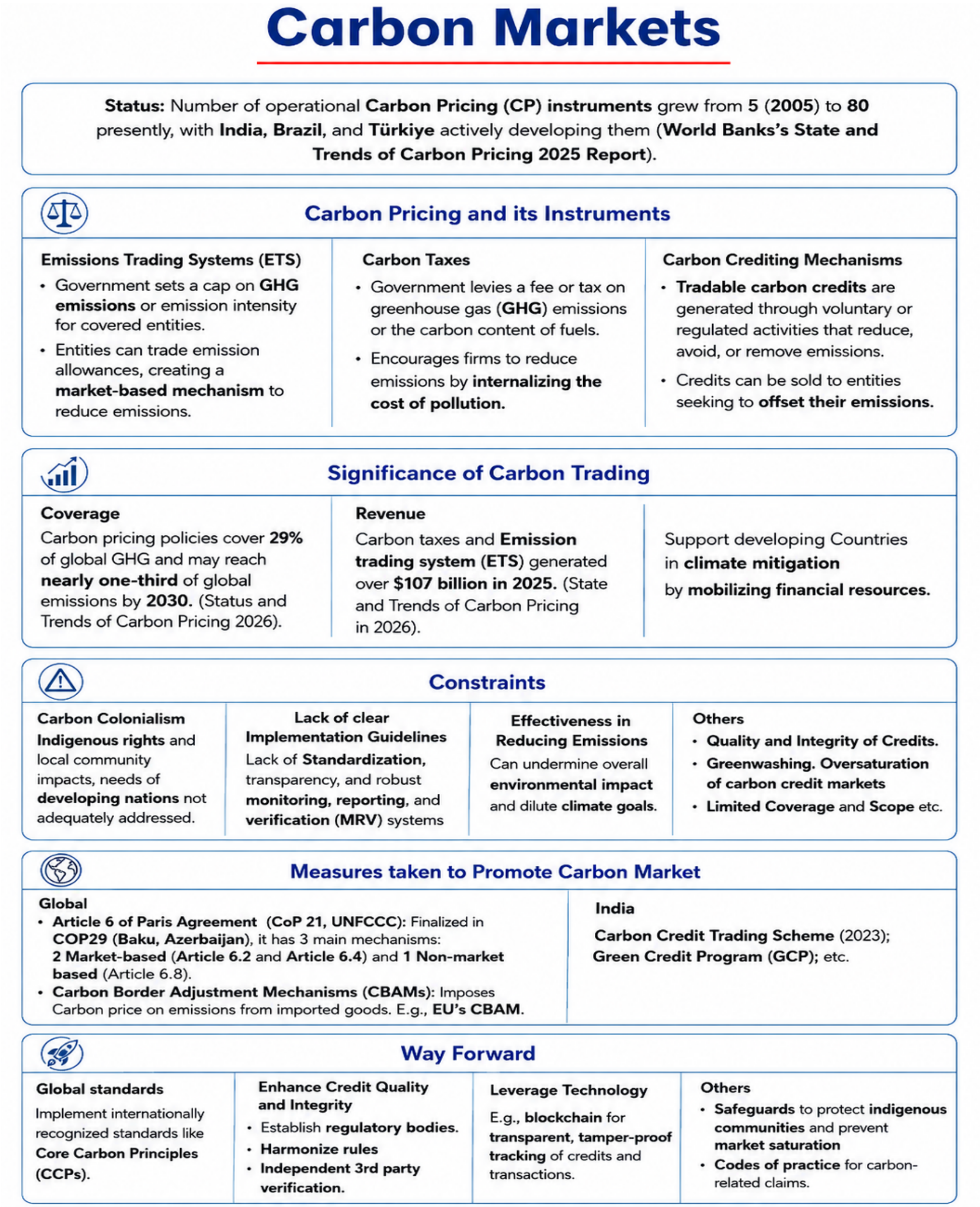
1.4. MITIGATION AND ADAPTATION

1.4.1. CARBON MARKETS AT A GLANCE



Carbon Markets

Status: Number of operational **Carbon Pricing (CP) instruments** grew from **5 (2005)** to **80** presently, with **India, Brazil,** and **Türkiye** actively developing them (**World Banks's State and Trends of Carbon Pricing 2025 Report**).

Carbon Pricing and its Instruments

Emissions Trading Systems (ETS)

- Government sets a cap on **GHG emissions** or emission intensity for covered entities.
- Entities can trade emission allowances, creating a **market-based mechanism** to reduce emissions.

Carbon Taxes

- Government levies a fee or tax on greenhouse gas (**GHG**) emissions or the carbon content of fuels.
- Encourages firms to reduce emissions by **internalizing the cost of pollution.**

Carbon Crediting Mechanisms

- **Tradable carbon credits** are generated through voluntary or regulated activities that reduce, avoid, or remove emissions.
- Credits can be sold to entities seeking to **offset their emissions.**

Significance of Carbon Trading

Coverage

Carbon pricing policies cover **29%** of global GHG and may reach **nearly one-third** of global emissions by **2030.** (Status and Trends of Carbon Pricing 2026).

Revenue

Carbon taxes and **Emission trading system (ETS)** generated over **$107 billion in 2025.** (State and Trends of Carbon Pricing in 2026).

Support developing Countries in **climate mitigation** by **mobilizing financial resources.**

Constraints

Carbon Colonialism

Indigenous rights and local community impacts, needs of **developing nations** not adequately addressed.

Lack of clear Implementation Guidelines

Lack of **Standardization,** transparency, and robust **monitoring, reporting,** and **verification (MRV)** systems

Effectiveness in Reducing Emissions

Can undermine overall **environmental impact** and dilute **climate goals.**

Others

- **Quality and Integrity of Credits.**
- **Greenwashing. Oversaturation of carbon credit markets**
- **Limited Coverage** and **Scope** etc.

Measures taken to Promote Carbon Market

Global

- **Article 6 of Paris Agreement (CoP 21, UNFCCC):** Finalized in **COP29 (Baku, Azerbaijan),** it has 3 main mechanisms: **2 Market-based (Article 6.2** and **Article 6.4)** and **1 Non-market based** (Article 6.8).
- **Carbon Border Adjustment Mechanisms (CBAMs):** Imposes Carbon price on emissions from imported goods. E.g., **EU's CBAM.**

India

Carbon Credit Trading Scheme (2023);
Green Credit Program (GCP); etc.

Way Forward

Global standards

Implement internationally recognized standards like **Core Carbon Principles (CCPs).**

Enhance Credit Quality and Integrity

- Establish **regulatory bodies.**
- **Harmonize rules**
- **Independent 3rd party verification.**

Leverage Technology

E.g., **blockchain** for **transparent, tamper-proof tracking** of credits and transactions.

Others

- **Safeguards** to protect **indigenous communities** and prevent **market saturation**
- **Codes of practice** for carbon-related claims.

1.4.2. GREENHOUSE GAS EMISSION INTENSITY (GEI) TARGET RULES

Why in the news?

Union Ministry of Environment, Forest, and Climate Change notified **Greenhouse Gases Emission Intensity Target (Amendment) Rules, 2025 under the Environment (Protection) Act, 1986.**

Key Details

- **Expansion:** Addition of **four new sectors - Petroleum Refinery, Petrochemicals, Textiles, and Secondary Aluminium,** to the list of obligated sectors to cut GHG emissions.
  - **Previous sectors** - Aluminium, Cement, Chlor-alkali, and Pulp & Paper.
- **Targets & Timeline:** New rules mandate 208 specific industrial units to reduce their GHG emission intensity (emissions per unit of product) starting from the compliance year 2025-26.
- **Reduction Goals:** The overall emission intensity reduction targets range from 3% to 7% by 2026-27 (baseline: 2023-24).
- **Compliance Mechanism:** Units failing to meet targets must purchase Carbon Credit Certificates (CCCs) to cover the shortfall.
  - Failure to do so attracts an **'environmental compensation' penalty equivalent to twice the average trading price** of CCCs.

About GEI Target Rules, 2025

- First **legally binding rules** issued under Compliance mechanism of **Carbon Credit Trading Scheme (CCTS), 2023**
  - GEI is **amount of GHGs emitted per unit of product output.** For instance, gases released in production of a tonne of product, like cement or aluminium.
- **Baseline-and-Credit model:** Each facility must reduce the amount of greenhouse gases emitted per unit of output compared to a 2023-24 baseline**.**
- **Compliance Enforced by**: Central Pollution Control Board (CPCB).
- **Objective:** To reduce **greenhouse gas emissions** per unit of output (tCO_2e per tonne of product) **in carbon-intensive sectors** and **facilitate carbon credit trading.**

About Carbon Credit Trading Scheme (CCTS)

- **Origin:** Notified by Union Ministry of Power in 2023 under Energy Conservation Act, 2001.
- **Objective:** Laid foundation for **Indian Carbon Market (ICM)** by establishing institutional framework.
- **Structure:**
  - **Administrator:** Bureau of Energy Efficiency (BEE) sets targets and issues CCCs.
  - **Regulator:** Central Electricity Regulatory Commission (CERC) regulates trading of CCCs.
  - **Registry:** Grid Controller of India Limited.
- **Operational Framework:** Functions through **Compliance Mechanism** (obligated entities meet GHG Emission Intensity targets; overachievers earn credits) **and Offset Mechanism** (non-obligated entities voluntarily register reduction projects to seek credits).
- **Mechanism:** Operates on 'Cap and Trade' model.
  - Obligated entities that reduce emissions beyond their target earn CCCs (1 CCC = 1 tonne of CO_2 equivalent), which can be traded on power exchanges.

Significance of rules

- **Operationalize the country's domestic carbon market** under CCTS, 2023.
- **Transparency** through registration and documentation under **Indian Carbon Market portal.**
- Uses Environmental compensation funds to **support carbon market infrastructure.**
- Aligns India's carbon market with **Article 6 of the Paris Agreement**
- Encourages the deployment of **clean and advanced technologies across traditionally high-emission industries.**

- Supports **India's commitments under Paris Agreement** (India's NDC- 47% Reduction in Emissions Intensity of GDP (from 2005 levels) by 2035).

Conclusion

Clear methodologies for emission targets, analysing existing market instruments, fungibility of trading units, and **strengthening institutional frameworks** are key to strengthening carbon market in India.

1.4.3. GREEN CREDIT PROGRAM

Why in the news?

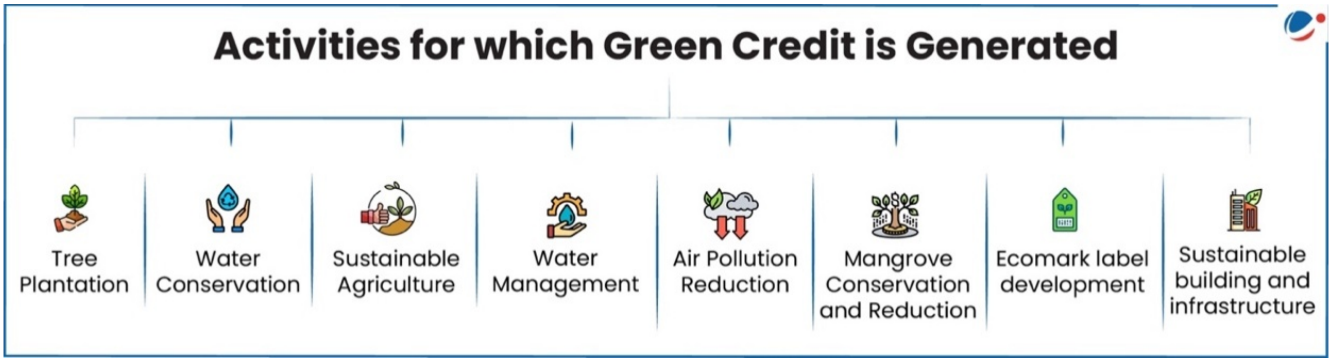
MOEFCC issued revised **methodology for calculating Green Credit** for tree plantation under Green Credit Rules, 2023.

Key Highlights of Revised Norms

- **Claim of Green Credit:** After 5 years of restoration on degraded forest land and achieving **at least 40% canopy** density.
  - **1 Green Credit = 1 new tree (over 5 years old).**
  - **Green Credits are** environmental rewards **representing positive environmental actions awarded to entities participating** in tree plantation initiatives.
  - Can be traded on dedicated exchange similar to carbon credits.
- **Credits** are **non-tradable and non-transferable**, except between a company and its subsidiaries.
- **Credits may be exchanged once for** meeting compensatory afforestation requirements, CSR obligations and project-specific legal plantation obligations.
- **Once exchanged, credits cannot be reused.**

About the Green Credit Program (GCP)

- Innovative **market-based mechanism** to encourage voluntary plantation activity for afforestation and water conservation.
- **Initiative within** the **Lifestyle for Environment or LIFE movement (Mission LIFE, 2021):**
  - India-led global mass movement to nudge individual/community for environment protection.
- **Established under**: "Environment (Protection) Act, 1986"
- **Nodal Agency**: Ministry of Environment, Forest and Climate Change of India (**MoEFCC).**
- **Objectives:**
  - **Land Bank Creation:** Through registration of degraded forest lands by Forest departments.
  - **Encourage Participation:** Government entities, Private companies, NGOs, Individuals/group of individuals (registered under the Societies Registration Act)
- **Governance Structure**
  - Supported by an **inter-ministerial Steering Committee.**
  - **Administrator:** Indian Council of Forestry Research and Education (ICFRE).


Activities for which Green Credit is Generated
Tree Plantation
Water Conservation
Sustainable Agriculture
Water Management
Air Pollution Reduction
Mangrove Conservation and Reduction
Ecomark label development
Sustainable building and infrastructure

Concerns Associated with GCP

- **Incentivizes forest diversion:** Companies can buy credits instead of restoring forests.
- **No real addition to forest cover:** Unlike compensatory afforestation (which requires converting non-forest land into forests), GCP allows existing degraded forest land to be used.
- **Evaluation and Long-term Sustainability:** Lacks clear criteria for evaluating plantation success, especially tree survivability, allowing **failed plantations to still earn credits.**

Way Forward

- Establishing Green Credit as **commodity derivative** like carbon credit for effective regulation.
- Establishing **Quantified Methodology** like carbon credit, equivalent to **one tonne of carbon dioxide equivalent.**
- Clearly **Defining Activities to prevent dual incentivisation** of the same activity for which carbon credits are issued.

Conclusion

Though a promising initiative, but its success will depend on the **clarity of methodologies and processes implemented** vis-à-vis the issuance and trading of green credits.

1.4.4. CARBON CAPTURE, UTILISATION AND STORAGE (CCUS)

Why in the News?

Union Budget 2026-27 announced an allocation of **Rs 20,000 crore** over next 5 years towards CCUS.

About CCUS

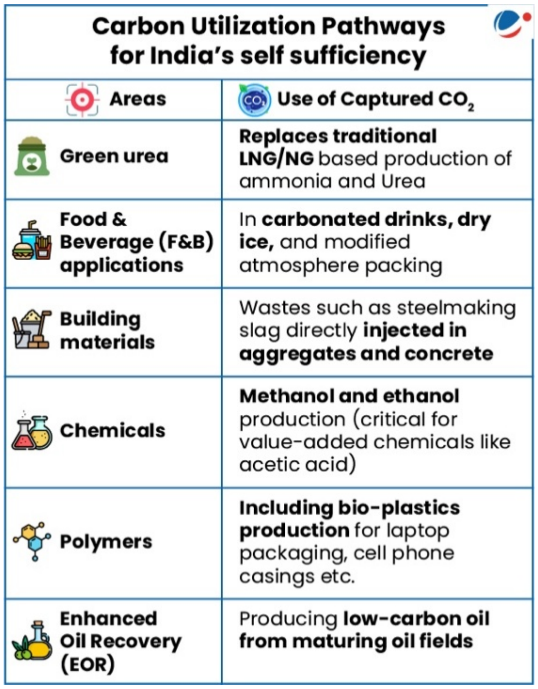
- Technologies to capture CO_2 from large stationary sources like power plants and industries (IEA).
    - **Goal:** Prevent captured CO_2 from re-entering atmosphere via storage or utilisation.
- **Capture techniques**: **Direct Air Capture (DAC), solvents** (chemical or physical), **Adsorption, Cryogenic separation** etc.
- **Storage**: Unutilized CO_2 is permanently trapped in geological storage like **EOR** (Enhanced Oil Recovery), **ECBMR** (Enhanced Coal Bed Methane Recovery) and permanent options like **saline aquifers and basalt storage**.
- **India's Target:** 750 mtpa (Million Tonne Per Annum) of CO_2 capture, utilization, and storage (NITI Aayog)

Significance of CCUS for India

- **Decarbonize hard to abate sectors:** steel, cement, oil & gas, fertilizers, etc.
- **Enabling sunrise sectors: Blue hydrogen** (i.e. coal gasification-based hydrogen production coupled with CCUS).
- **Circular Carbon Economy:** Conversion of captured carbon into **value-added products** (see infographic).
- **Net-Zero Emissions Targets:** Requires sequestering **11.4 GtCO2e** cumulatively till **2070.**

Challenges associated with implementing CCUS

- **High Costs:** US$ 100-150 billion for 750 mtpa of CO_2 capture, utilization, and storage.
- **Geological Storage Risks:** Forcefully CO_2 injection can fracture rock and induce seismicity.



Carbon Utilization Pathways for India's self sufficiency

Areas	Use of Captured CO_2
Green urea	**Replaces traditional LNG/NG** based production of ammonia and Urea
Food & Beverage (F&B) applications	In **carbonated drinks, dry ice,** and modified atmosphere packing
Building materials	Wastes such as steelmaking slag directly **injected in aggregates and concrete**
Chemicals	**Methanol and ethanol** production (critical for value-added chemicals like acetic acid)
Polymers	**Including bio-plastics production** for laptop packaging, cell phone casings etc.
Enhanced Oil Recovery (EOR)	Producing **low-carbon oil from maturing oil fields**

- **Others**: Technically complex retrofitting; lack of clear legal frameworks; limited geological data on pore space availability, etc.

Way forward to implement CCUS in India

- **Incentivize & de-risk CCUS projects:** Enhance private funding; government funding like Clean Energy Cess, low cost sovereign or international Green Funds, etc.
- **Draft national CCS regulations:** Covering entire CCUS value chain.
- **Mapping storage site:** Characterise geological storage potential across priority basins.
- **Others: Promote R&D in novel CO_2 utilization technologies; Knowledge sharing** through Mission Innovation; Machine Learning for Geological Data Analysis, Hub and cluster model, etc.

Conclusion

High costs, technological gaps, and regulatory issues must be addressed through **strong policy support, innovation, and private participation** to enable its effective deployment.

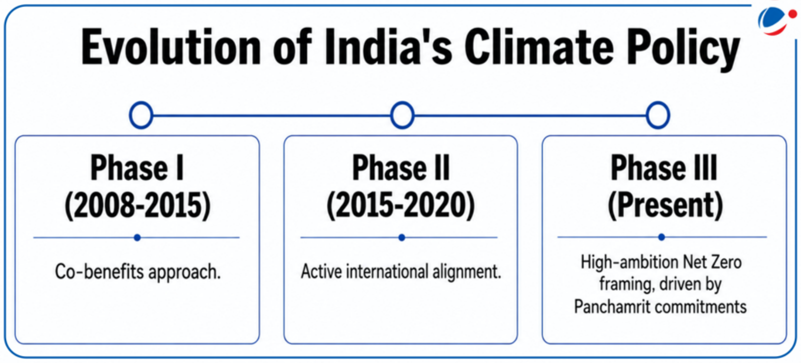
1.4.5. NITI AAYOG REPORT: SCENARIOS TOWARDS VIKSIT BHARAT AND NET ZERO

Why in the News?

NITI Aayog released an **11-volume report** titled "**Scenarios Towards Viksit Bharat and Net Zero"** detailing long-term, multi-sectoral transition pathways.

India's Current Energy and Emission Profile

- **Historical Contribution:** India's per-capita GHG emissions stand at **2.9 tCO2e**, (global average 6.7 tCO2e).
- **Fossil Fuel:** In 2024-25, fossil fuels supplied **87% of India's total primary energy**, heavily reliant on coal (54%) and oil (26%).
- **Decoupling Growth:** India already achieved **36% reduction in GHG emissions intensity of GDP** between 2005-2020, demonstrating an **initial decoupling** of economic growth from carbon output.


Evolution of India's Climate Policy
Phase I (2008-2015)
Co-benefits approach.
Phase II (2015-2020)
Active international alignment.
Phase III (Present)
High-ambition Net Zero framing, driven by Panchamrit commitments

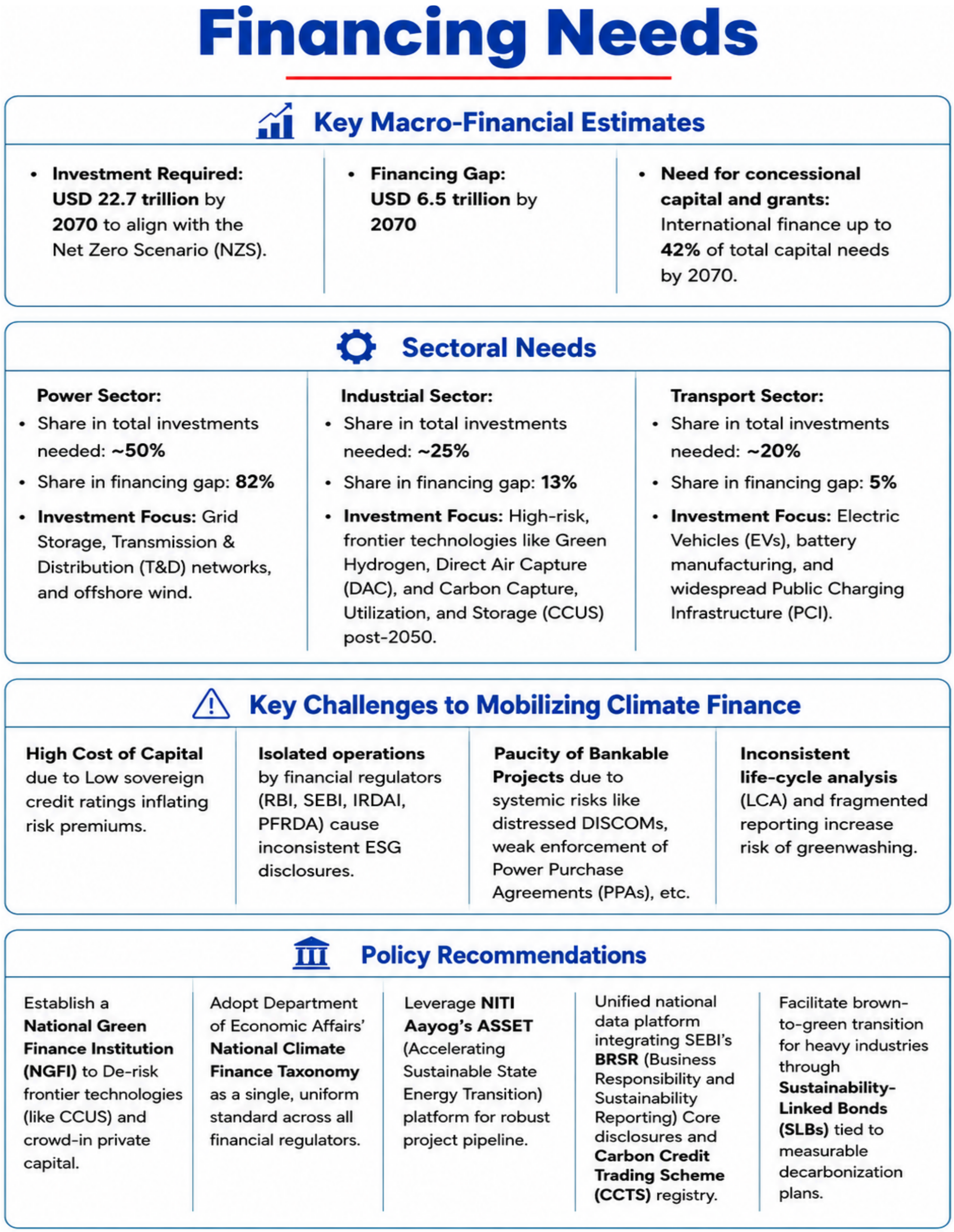
Emerging Challenges and Vulnerabilities

- **Residual Emissions:** India is projected to retain ~1.3 GtCO$_2$e of emissions by 2070, primarily from agriculture, cement, and heavy industry.
- **Land and Water Constraints:** NZS power infrastructure will require **5.92 Mha of land by 2070** (equivalent to ~11% of India's assessed wastelands).
- **Public Health:** Rising temperatures exacerbate **Urban Heat Island effects** and **vector-borne diseases**.
- **Social and Workforce Transition:** Over **150 districts** and millions of informal workers depend on the fossil-fuel economy (coal mining, thermal power).

Conclusion

The pursuit of both development and climate targets presents a historic opportunity for India to build a sustainable, prosperous, and resilient future.

1.4.5.1. SECTORAL INSIGHTS: FINANCING NEEDS AT A GLANCE



Financing Needs

Key Macro-Financial Estimates

- **Investment Required:** **USD 22.7 trillion** by **2070** to align with the Net Zero Scenario (NZS).
- **Financing Gap:** **USD 6.5 trillion** by **2070**
- **Need for concessional capital and grants:** International finance up to **42%** of total capital needs by 2070.

Sectoral Needs

Power Sector:

- Share in total investments needed: **~50%**
- Share in financing gap: **82%**
- **Investment Focus:** Grid Storage, Transmission & Distribution (T&D) networks, and offshore wind.

Industrial Sector:

- Share in total investments needed: **~25%**
- Share in financing gap: **13%**
- **Investment Focus:** High-risk, frontier technologies like Green Hydrogen, Direct Air Capture (DAC), and Carbon Capture, Utilization, and Storage (CCUS) post-2050.

Transport Sector:

- Share in total investments needed: **~20%**
- Share in financing gap: **5%**
- **Investment Focus:** Electric Vehicles (EVs), battery manufacturing, and widespread Public Charging Infrastructure (PCI).

Key Challenges to Mobilizing Climate Finance

High Cost of Capital due to Low sovereign credit ratings inflating risk premiums.

Isolated operations by financial regulators (RBI, SEBI, IRDAI, PFRDA) cause inconsistent ESG disclosures.

Paucity of Bankable Projects due to systemic risks like distressed DISCOMs, weak enforcement of Power Purchase Agreements (PPAs), etc.

Inconsistent life-cycle analysis (LCA) and fragmented reporting increase risk of greenwashing.

Policy Recommendations

Establish a **National Green Finance Institution (NGFI)** to De-risk frontier technologies (like CCUS) and crowd-in private capital.

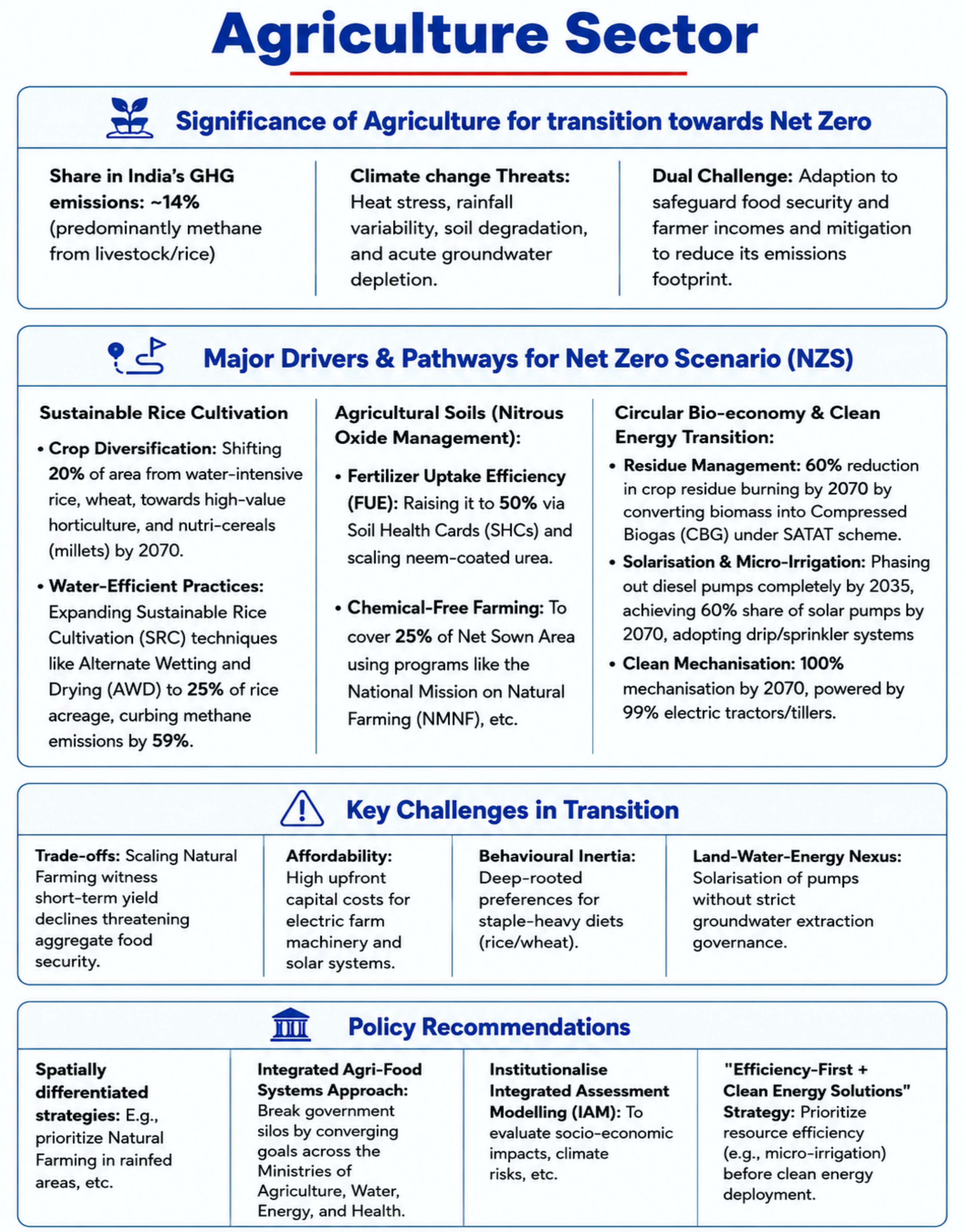
Adopt Department of Economic Affairs' **National Climate Finance Taxonomy** as a single, uniform standard across all financial regulators.

Leverage **NITI Aayog's ASSET** (Accelerating Sustainable State Energy Transition) platform for robust project pipeline.

Unified national data platform integrating SEBI's **BRSR** (Business Responsibility and Sustainability Reporting) Core disclosures and **Carbon Credit Trading Scheme (CCTS)** registry.

Facilitate brown-to-green transition for heavy industries through **Sustainability-Linked Bonds (SLBs)** tied to measurable decarbonization plans.

1.4.5.2. SECTORAL INSIGHTS: AGRICULTURE SECTOR AT A GLANCE



Agriculture Sector

Significance of Agriculture for transition towards Net Zero

Share in India's GHG emissions: ~14% (predominantly methane from livestock/rice)

Climate change Threats: Heat stress, rainfall variability, soil degradation, and acute groundwater depletion.

Dual Challenge: Adaption to safeguard food security and farmer incomes and mitigation to reduce its emissions footprint.

Major Drivers & Pathways for Net Zero Scenario (NZS)

Sustainable Rice Cultivation

- **Crop Diversification:** Shifting **20%** of area from water-intensive rice, wheat, towards high-value horticulture, and nutri-cereals (millets) by 2070.
- **Water-Efficient Practices:** Expanding Sustainable Rice Cultivation (SRC) techniques like Alternate Wetting and Drying (AWD) to **25%** of rice acreage, curbing methane emissions by **59%.**

Agricultural Soils (Nitrous Oxide Management):

- **Fertilizer Uptake Efficiency (FUE):** Raising it to **50%** via Soil Health Cards (SHCs) and scaling neem-coated urea.
- **Chemical-Free Farming:** To cover **25%** of Net Sown Area using programs like the National Mission on Natural Farming (NMNF), etc.

Circular Bio-economy & Clean Energy Transition:

- **Residue Management: 60%** reduction in crop residue burning by 2070 by converting biomass into Compressed Biogas (CBG) under SATAT scheme.
- **Solarisation & Micro-Irrigation:** Phasing out diesel pumps completely by 2035, achieving 60% share of solar pumps by 2070, adopting drip/sprinkler systems
- **Clean Mechanisation: 100%** mechanisation by 2070, powered by 99% electric tractors/tillers.

Key Challenges in Transition

Trade-offs: Scaling Natural Farming witness short-term yield declines threatening aggregate food security.

Affordability: High upfront capital costs for electric farm machinery and solar systems.

Behavioural Inertia: Deep-rooted preferences for staple-heavy diets (rice/wheat).

Land-Water-Energy Nexus: Solarisation of pumps without strict groundwater extraction governance.

Policy Recommendations

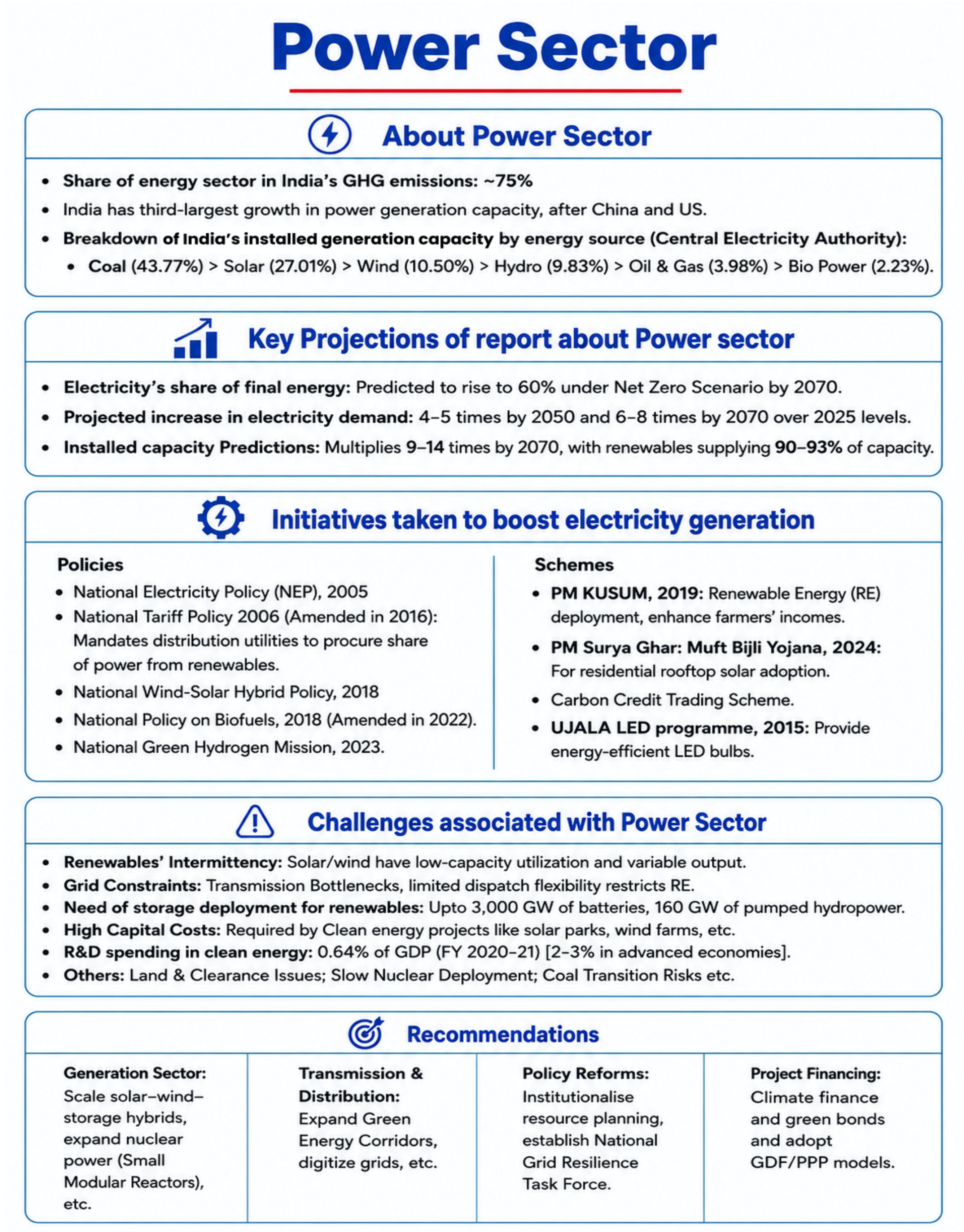
Spatially differentiated strategies: E.g., prioritize Natural Farming in rainfed areas, etc.

Integrated Agri-Food Systems Approach: Break government silos by converging goals across the Ministries of Agriculture, Water, Energy, and Health.

Institutionalise Integrated Assessment Modelling (IAM): To evaluate socio-economic impacts, climate risks, etc.

"Efficiency-First + Clean Energy Solutions" Strategy: Prioritize resource efficiency (e.g., micro-irrigation) before clean energy deployment.

1.4.5.3. SECTORAL INSIGHTS: POWER SECTOR AT A GLANCE



Power Sector

About Power Sector

- **Share of energy sector in India's GHG emissions: ~75%**
- India has third-largest growth in power generation capacity, after China and US.
- **Breakdown of India's installed generation capacity by energy source (Central Electricity Authority):**
  - **Coal** (43.77%) > Solar (27.01%) > Wind (10.50%) > Hydro (9.83%) > Oil & Gas (3.98%) > Bio Power (2.23%).

Key Projections of report about Power sector

- **Electricity's share of final energy:** Predicted to rise to 60% under Net Zero Scenario by 2070.
- **Projected increase in electricity demand:** 4–5 times by 2050 and 6–8 times by 2070 over 2025 levels.
- **Installed capacity Predictions:** Multiplies **9–14** times by 2070, with renewables supplying **90–93%** of capacity.

Initiatives taken to boost electricity generation

Policies

- National Electricity Policy (NEP), 2005
- National Tariff Policy 2006 (Amended in 2016): Mandates distribution utilities to procure share of power from renewables.
- National Wind-Solar Hybrid Policy, 2018
- National Policy on Biofuels, 2018 (Amended in 2022).
- National Green Hydrogen Mission, 2023.

Schemes

- **PM KUSUM, 2019:** Renewable Energy (RE) deployment, enhance farmers' incomes.
- **PM Surya Ghar: Muft Bijli Yojana, 2024:** For residential rooftop solar adoption.
- Carbon Credit Trading Scheme.
- **UJALA LED programme, 2015:** Provide energy-efficient LED bulbs.

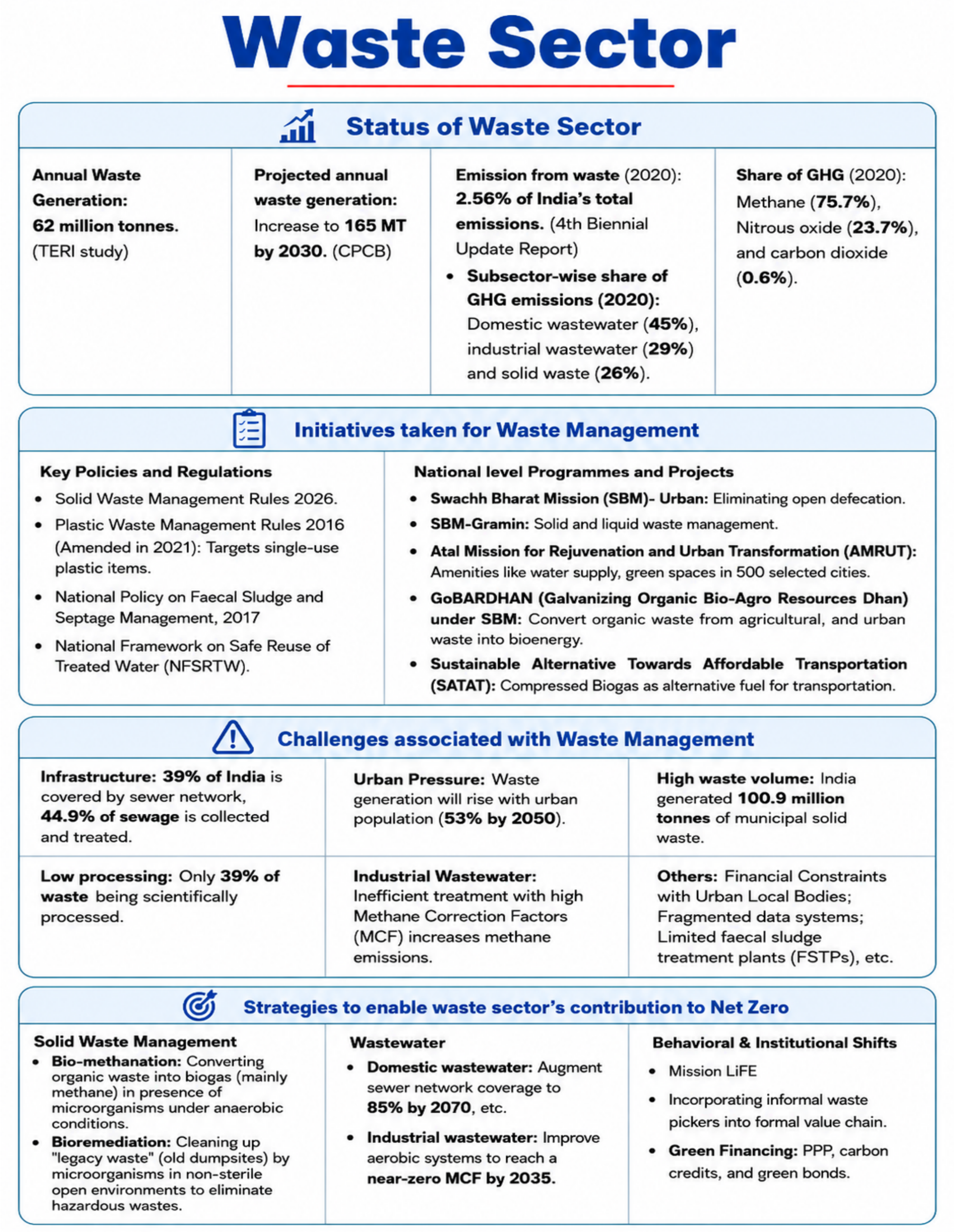
Challenges associated with Power Sector

- **Renewables' Intermittency:** Solar/wind have low-capacity utilization and variable output.
- **Grid Constraints:** Transmission Bottlenecks, limited dispatch flexibility restricts RE.
- **Need of storage deployment for renewables:** Upto 3,000 GW of batteries, 160 GW of pumped hydropower.
- **High Capital Costs:** Required by Clean energy projects like solar parks, wind farms, etc.
- **R&D spending in clean energy:** 0.64% of GDP (FY 2020-21) [2-3% in advanced economies].
- **Others:** Land & Clearance Issues; Slow Nuclear Deployment; Coal Transition Risks etc.

Recommendations

Generation Sector:	**Transmission & Distribution:**	**Policy Reforms:**	**Project Financing:**
Scale solar–wind–storage hybrids, expand nuclear power (Small Modular Reactors), etc.	Expand Green Energy Corridors, digitize grids, etc.	Institutionalise resource planning, establish National Grid Resilience Task Force.	Climate finance and green bonds and adopt GDF/PPP models.

1.4.5.4. SECTORAL INSIGHTS: WASTE SECTOR AT A GLANCE



Waste Sector

Status of Waste Sector

Annual Waste Generation: 62 million tonnes. (TERI study)

Projected annual waste generation: Increase to **165 MT by 2030.** (CPCB)

Emission from waste (2020): **2.56% of India's total emissions.** (4th Biennial Update Report)

- **Subsector-wise share of GHG emissions (2020):** Domestic wastewater (**45%**), industrial wastewater (**29%**) and solid waste (**26%**).

Share of GHG (2020): Methane (**75.7%**), Nitrous oxide (**23.7%**), and carbon dioxide (**0.6%**).

Initiatives taken for Waste Management

Key Policies and Regulations

- Solid Waste Management Rules 2026.
- Plastic Waste Management Rules 2016 (Amended in 2021): Targets single-use plastic items.
- National Policy on Faecal Sludge and Septage Management, 2017
- National Framework on Safe Reuse of Treated Water (NFSRTW).

National level Programmes and Projects

- **Swachh Bharat Mission (SBM)- Urban:** Eliminating open defecation.
- **SBM-Gramin:** Solid and liquid waste management.
- **Atal Mission for Rejuvenation and Urban Transformation (AMRUT):** Amenities like water supply, green spaces in 500 selected cities.
- **GoBARDHAN (Galvanizing Organic Bio-Agro Resources Dhan) under SBM:** Convert organic waste from agricultural, and urban waste into bioenergy.
- **Sustainable Alternative Towards Affordable Transportation (SATAT):** Compressed Biogas as alternative fuel for transportation.

Challenges associated with Waste Management

Infrastructure: 39% of India is covered by sewer network, **44.9% of sewage** is collected and treated.

Urban Pressure: Waste generation will rise with urban population (**53% by 2050**).

High waste volume: India generated **100.9 million tonnes** of municipal solid waste.

Low processing: Only **39% of waste** being scientifically processed.

Industrial Wastewater: Inefficient treatment with high Methane Correction Factors (MCF) increases methane emissions.

Others: Financial Constraints with Urban Local Bodies; Fragmented data systems; Limited faecal sludge treatment plants (FSTPs), etc.

Strategies to enable waste sector's contribution to Net Zero

Solid Waste Management

- **Bio-methanation:** Converting organic waste into biogas (mainly methane) in presence of microorganisms under anaerobic conditions.
- **Bioremediation:** Cleaning up "legacy waste" (old dumpsites) by microorganisms in non-sterile open environments to eliminate hazardous wastes.

Wastewater

- **Domestic wastewater:** Augment sewer network coverage to **85% by 2070**, etc.
- **Industrial wastewater:** Improve aerobic systems to reach a **near-zero MCF by 2035.**

Behavioral & Institutional Shifts

- Mission LiFE
- Incorporating informal waste pickers into formal value chain.
- **Green Financing:** PPP, carbon credits, and green bonds.

1.4.6. INDUSTRIAL DECARBONISATION

Why in the news?

Decarbonisation of key sectors including Cement, Aluminium, MSMEs and other hard to abate sectors is essential to achieve India's climate goals.

Significance of Decarbonisation of Key Industrial Sectors

- **Contribution to India's total GHG emissions:** Cement sector: ~6%; Aluminium sector: ~2.8 %
- **MSMEs rely heavily on fossil fuels**: Contributed ~**135 million tonnes** of carbon emissions (MtCO2e) in 2022.
- **Mitigate export risks:** From emerging trade regulations, i.e. EU's CBAM.
- **Rising emissions:** India's **share in global carbon emissions** rose from **2.5% in 1990** to an estimated **8.2% in 2023**. (Despite lower than global average per capita emissions).
- **Economic Risks: Potential per capita GDP losses ranging from 2.0% in 2030 to 3-9% by 2047** due to climate change.

Recommended Roadmaps for Key Sectors

- **Aluminium:** Transition **to RE-RTC (Renewable Energy-Round-the-Clock) power** and Grid connection; adopt nuclear power; CCUS, etc.
- **Cement:** Increase **Refuse-Derived Fuel (RDF)** usage from municipal solid waste to expect 80-85% reduction in GHG emissions by 2070.
- **MSMEs:** National Programme for Green Transition of MSMEs; Scaling up of Energy Efficiency to reduce 75-87 MtCO2e GHG.
- **Coal Sector: Afforestation** of mined-out areas; **Treated Mine Water Utilization** for **community supply** like irrigation, **industrial uses; Blast Free mining technology, etc.**
- **Other Key Recommendations:**
    - **Incentivize private investment:** India's total climate finance requirement for substantial decarbonization of four key sectors (power, road transport, steel, and cement) averages around 1.3% of GDP annually.
    - **Government measures** to develop crucial infrastructure like EV charging systems, etc.

Conclusion

Industrial decarbonisation represents a 'triple win' for India—achieving climate goals, strengthening economic competitiveness, and fostering sustainable and inclusive growth.

1.4.7. METHANE EMISSIONS

Why in the news?

Global Methane Status Report 2025 recently released by **UN Environment Programme (UNEP)** and **Climate and Clean Air Coalition (CCAC),** highlights progress made since **Global Methane Pledge.**

About Methane

- **84 times more potent** than carbon dioxide over a 20-year period.
- Second **most significant contributor to anthropogenic warming after carbon dioxide**.
- **Short-lived climate pollutant (SLCP)** with an atmospheric lifespan of around 12 years.
- Major Precursor to **Ground-level Ozone.**
- **Key Sources of Methane Emissions**
    - **Agriculture** (enteric fermentation in livestock, manure management and rice production)
    - **Energy** (use of fossil fuels, coal mines, and leakages from natural gas and oil production).
    - **Landfill Emissions** (Responsible for around 11% of all human-made emissions; containing toxic components like VOCs, Hydrogen Sulphide, etc.).

Status of Methane Emissions

- **Methane's atmospheric Concentrations:** More than **doubled** since pre-industrial times reaching approximately **352 million tonnes (Mt) per year in 2020.**
- **Impact:** Contribute to **24,000 additional premature deaths** and **2.5 Mt of crop losses** annually by 2030 relative to 2020.
    - Methane becomes explosive at concentrations of **4.4%–16.5% in air** triggering prolonged fire.
- **Emission in India:** India is **world's third-largest methane emitter** (driven by Stubble burning) after China and the United States.

Measures to tackle Methane Emissions

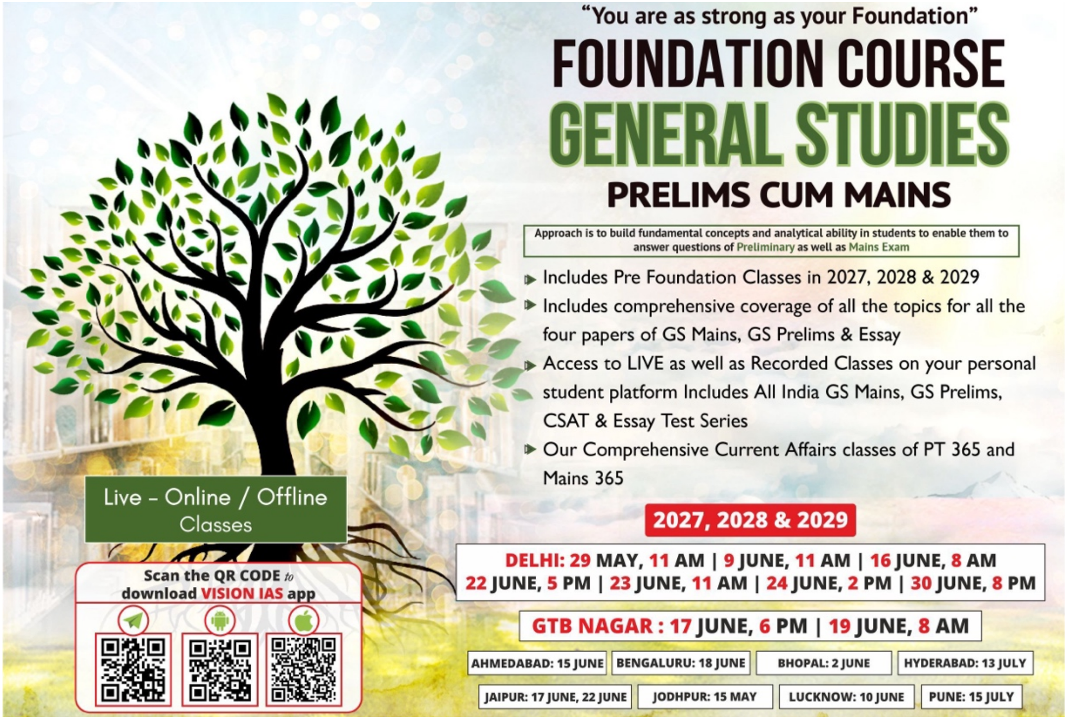
- **Global: Global Methane Pledge (GMP)-** Reduce methane emissions by 30% from 2020 levels by 2030. (Not signed by India); International Methane Emissions Observatory (IMEO)- Led by UNEP.
- **India**: National **Mission on Sustainable Agriculture (NMSA); System for Rice Intensification; Direct Seeded Rice** (does not maintain standing water while transplanting paddy); etc.

Suggested interventions for managing methane emissions from waste

- **Satellite Monitoring: Using regional-scale data** to track broad methane trends.
    - In 2023, ISRO satellite study identified major methane emitters at **Pirana (Gujarat)** and **Deonar and Kanjurmarg (Maharashtra), Ghazipur (Delhi) etc.**
- **Strengthen Source Segregation of Wastes (SBM–Urban & Gramin):** Into wet, dry and hazardous.
- **Promote Waste-to-Energy & Bio-CNG (GOBARdhan):** Using wet waste to capture methane.
- **Scientific Landfills (Solid Waste Management Rules, 2016):** Replace open dumps with engineered landfills.
- **Use of Bio-covers:** A microbial system using **naturally occurring bacteria to oxidize methane** into less harmful carbon dioxide and water.
    - Capable of **mitigating up to 50% of the methane generation** over a 100-year period.

Conclusion

It is important for countries to **drive momentum on methane mitigation**, turning ambition into tangible benefits as every tonne reduced brings us closer to cleaner air and resilient society.



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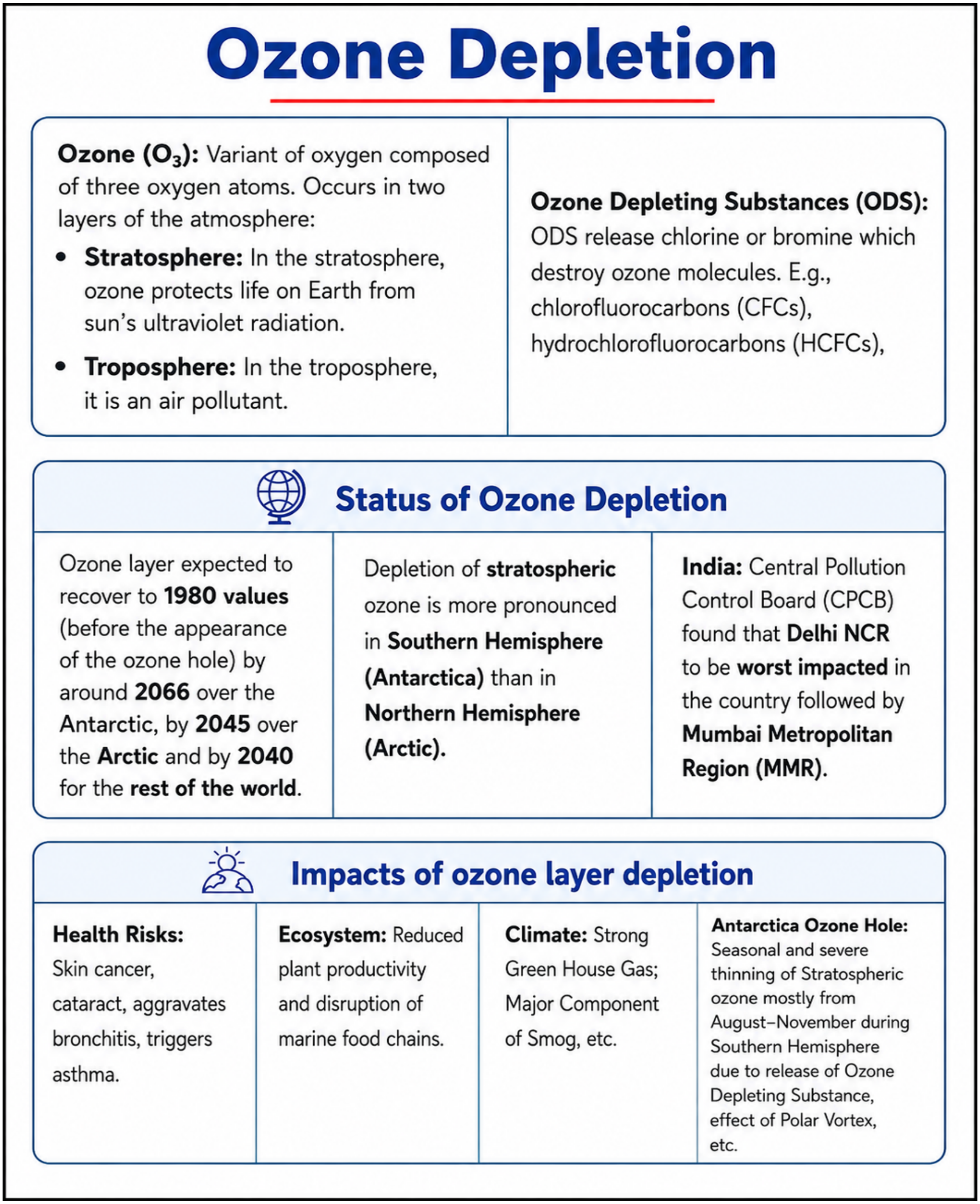
22 JUNE, 5 PM | 23 JUNE, 11 AM | 24 JUNE, 2 PM | 30 JUNE, 8 PM

GTB NAGAR : 17 JUNE, 6 PM | 19 JUNE, 8 AM

AHMEDABAD: 15 JUNE | BENGALURU: 18 JUNE | BHOPAL: 2 JUNE | HYDERABAD: 13 JULY
JAIPUR: 17 JUNE, 22 JUNE | JODHPUR: 15 MAY | LUCKNOW: 10 JUNE | PUNE: 15 JULY

1.5. MISCELLANEOUS

1.5.1. OZONE DEPLETION AT A GLANCE



Ozone Depletion

Ozone (O_3): Variant of oxygen composed of three oxygen atoms. Occurs in two layers of the atmosphere:

- **Stratosphere:** In the stratosphere, ozone protects life on Earth from sun's ultraviolet radiation.
- **Troposphere:** In the troposphere, it is an air pollutant.

Ozone Depleting Substances (ODS): ODS release chlorine or bromine which destroy ozone molecules. E.g., chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs),

Status of Ozone Depletion

Ozone layer expected to recover to **1980 values** (before the appearance of the ozone hole) by around **2066** over the Antarctic, by **2045** over the **Arctic** and by **2040** for the **rest of the world**.

Depletion of **stratospheric** ozone is more pronounced in **Southern Hemisphere (Antarctica)** than in **Northern Hemisphere (Arctic).**

India: Central Pollution Control Board (CPCB) found that **Delhi NCR** to be **worst impacted** in the country followed by **Mumbai Metropolitan Region (MMR).**

Impacts of ozone layer depletion

Health Risks: Skin cancer, cataract, aggravates bronchitis, triggers asthma.

Ecosystem: Reduced plant productivity and disruption of marine food chains.

Climate: Strong Green House Gas; Major Component of Smog, etc.

Antarctica Ozone Hole: Seasonal and severe thinning of Stratospheric ozone mostly from August–November during Southern Hemisphere due to release of Ozone Depleting Substance, effect of Polar Vortex, etc.

1.5.2. MONTREAL PROTOCOL

Why in the news?

Union Environment Ministry directed all state/Central authorities to **stop granting environmental clearances for HFCs production** to new/additional HFC production beyond 2027 to fulfil commitments under **Kigali Amendment.**

About Kigali Amendment and Montreal Protocol

- **Kigali Amendment to Montreal Protocol** was adopted in **2016** for phase-down of hydrofluorocarbons (HFCs), a greenhouse gas used as a substitute for ODS.
  - **Key Targets:**
    - Parties agreed to **reduce HFCs by 80–85% by the late 2040s**.
    - India will complete its phase-down of HFCs in 4 steps from 2032 onwards with cumulative reduction **of 10% (2032), 20% (2037), 30% (2042) and 85% (2047).**
- **Montreal Protocol 1987: Universally ratified** treaty that set binding phase-out targets for ODS and **achieved over 98% reduction** compared to 1990 levels.
- **Vienna Convention 1985:** first global treaty **recognizing stratospheric ozone depletion as a problem** that paved the way for Montreal Protocol.

India's Achievements under Montreal Protocol

- **Early ODS Phase-Out:** Phased out chlorofluorocarbons (CFCs), carbon tetrachloride (CTC), and halons for controlled use by 2010.
- **Policy Framework:** Enacted Ozone Depleting Substances (ODS) (Regulation and Control) Rules in 2000, banning CFCs and halons in new equipment by 2003.
- **Hydrochlorofluorocarbon (HCFC) Phase-out:** Achieved **67.5% reduction in HCFC production & consumption** and complete phase out of **HCFC-141b (2020).**

Conclusion

India's **proactive measures, early phase-outs, and sustained commitment** reflect how countries can contribute to both environmental protection and climate action.

1.5.3. LAND-BASED CARBON REMOVAL (LBCR)

Why in the News?

Present government climate pledges propose using approximately **1.01 billion ha of land** for Land Based Carbon Removal.

About Land Based Carbon Removal (LBCR)

- LBCR refers to strategies that **use terrestrial ecosystems** primarily forests, soils, wetlands, and agricultural landscapes to **absorb and store carbon dioxide from the atmosphere.**
- Climate pledges rely excessively on LBCR requiring 1 billion ha of land. (Land Gap Report 2025)

Methods of LBCR

- **Reforestation and Afforestation**: Can **mitigate 0.5–10.1 gigatonnes of CO_2** per year. (IPCC)
- **Soil Carbon Sequestration:** Process of capturing atmospheric CO_2 and storing it in soils as soil organic carbon (SOC).
- **Bioenergy with Carbon Capture and Storage (BECCS)**: Energy crops like silver grass are grown, burned as fuel for bioenergy, and resulting CO_2 emissions are captured and stored underground.
- **Geologic Carbon Sequestration**: Captured CO_2 either from direct air capture or biogenic sources is injected deep underground into porous rock formations for long-term storage.
- **Biochar**: Burning biomass in an oxygen-limited environment producing more stable form of carbon, which is applied to soils – adding nutrients and increasing soil's carbon stocks.

- **Enhanced Weathering**: Accelerating the natural reaction between carbon dioxide and reactive sources, such as certain types of rocks, to increase carbon uptake.

Potential issues

- **Competition for land**: Inappropriate deployment at large scales can limit land for biodiversity conservation and food, e.g., in case of afforestation, growing energy crops etc.
- **Reduced biodiversity and Increased eutrophication**: If fertiliser use and introduced species are involved, e.g., for reforestation.
- **Competition for biomass:** E.g., BECCS can limit availability for other industries.
- **Dust emissions**: E.g., in case of enhance weathering.

Conclusion

Land-based carbon removal is a valuable climate tool, but it cannot replace deep and immediate emission cuts; balancing climate mitigation with land, food, and biodiversity needs is essential.

1.5.4. CARBON BORDER ADJUSTMENT MECHANISM (CBAM)

Why in the News?

EU implemented the **world's first carbon tax**, the **Carbon Border Adjustment Mechanism (CBAM)** from January 1, 2026.

About CBAM

- European Union's (EU) policy to impose a **carbon tax** on imports of certain products from countries with less stringent climate policies.
- **Sectors Covered:** Cement, aluminium, fertilisers, iron and steel, hydrogen and electricity.

Significance of CBAM

- Support **decarbonisation of EU.**
- **Prevent Carbon Leakage** by stopping firms from shifting production to countries with weaker climate rules.
- **Fair price on carbon emitted from carbon-intensive goods** that are entering the EU.
- **Encourage cleaner industrial production** in non-EU countries.

India's Concerns

- Create **new trade barriers for exports** to EU.
- CBAM tax burden would **represent 0.05% of India's GDP** (Centre for Science and Environment).
- **Disproportionate burden** on small and medium enterprises (SMEs) compared to larger ones.
- **Stringent compliance requirements**, emissions tracking, certifications, digital filings, and verification protocols

Conclusion

CBAM's climate ambition is noble, but **execution is bureaucratically extractive**. However, the idea that EU will set standards for other countries is opposed by India.

1.6. KEYWORDS

Belém Mission	Climate Justice	Green Credit	Deglaciation	Climate Finance
Land Based Carbon Removal	Greenhouse Gases Emission Intensity Target (Amendment) Rules	Industrial Decarbonization	Nationally Determined Contributions (NDCs)	Carbon Capture, Utilization and Storage (CCUS)

Net Zero	Carbon Market	Montreal Protocol	Ocean Acidification	Carbon Border Adjustment Mechanism (CBAM)
Article 6	Common but Differentiated Responsibilities (CBDR-RC)	Global Goal on Adaptation (GGA)	Ocean Warming	Emissions Trading Systems (ETS)

1.7. PRACTICE QUESTION

Mention the recent updates on India's National Determined Contributions (NDCs) along with key progress made on them. Also suggest the key measures taken towards fulfilment of these targets along with India's stance towards the issue of climate change.

Introduction	Body Part 1	Body Part 2	Conclusion
Briefly mention about NDCs, their nature and association with UNFCCC.	Mention about India's updated NDCs comprising of targets for 2035 and updates for 2030 along with the progress made.	Outline key measures taken by India and suggest India's stance towards climate justice.	Suggest what more could be done in case of finance mobilisation, developing capacity, etc.

फाउंडेशन कोर्स
सामान्य अध्ययन
प्रारंभिक एवं मुख्य परीक्षा 2027

इनोवेटिव क्लासरूम प्रोग्राम

- प्रारंभिक परीक्षा, मुख्य परीक्षा और निबंध के लिए महत्वपूर्ण सभी टॉपिक का विस्तृत कवरेज
- मौलिक अवधारणाओं की समझ के विकास एवं विश्लेषणात्मक क्षमता निर्माण पर विशेष ध्यान
- एनीमेशन, पॉवर प्वाइंट, वीडियो जैसी तकनीकी सुविधाओं का प्रयोग
- अंतर - विषयक समझ विकसित करने का प्रयास
- योजनाबद्ध तैयारी हेतु करेंट ओरिएंटेड अप्रोच
- नियमित क्लास टेस्ट एवं व्यक्तिगत मूल्यांकन
- प्री फाउंडेशन कक्षाएं
- सीसैट कक्षाएं
- PT 365 कक्षाएं
- MAINS 365 कक्षाएं
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- सीसैट टेस्ट सीरीज
- निबंध लेखन - शैली की कक्षाएं
- करेंट अफेयर्स मैगजीन

नोट: ऑनलाइन छात्र हमारे पाठ्यक्रम की लाइव वीडियो कक्षाएं अपने घर पर ऑनलाइन प्लेटफॉर्म पर देख सकते हैं। छात्र लाइव चैट विकल्प के माध्यम से कक्षा के दौरान अपने संदेह और विषय संबंधी प्रश्न पूछ सकते हैं। वे अपने संदेह और प्रश्न नोट भी कर सकते हैं और दिल्ली केंद्र में हमारे कक्षा सलाहकार को बता सकते हैं और हम फोन/मेल के माध्यम से प्रश्नों का उत्तर देंगे।

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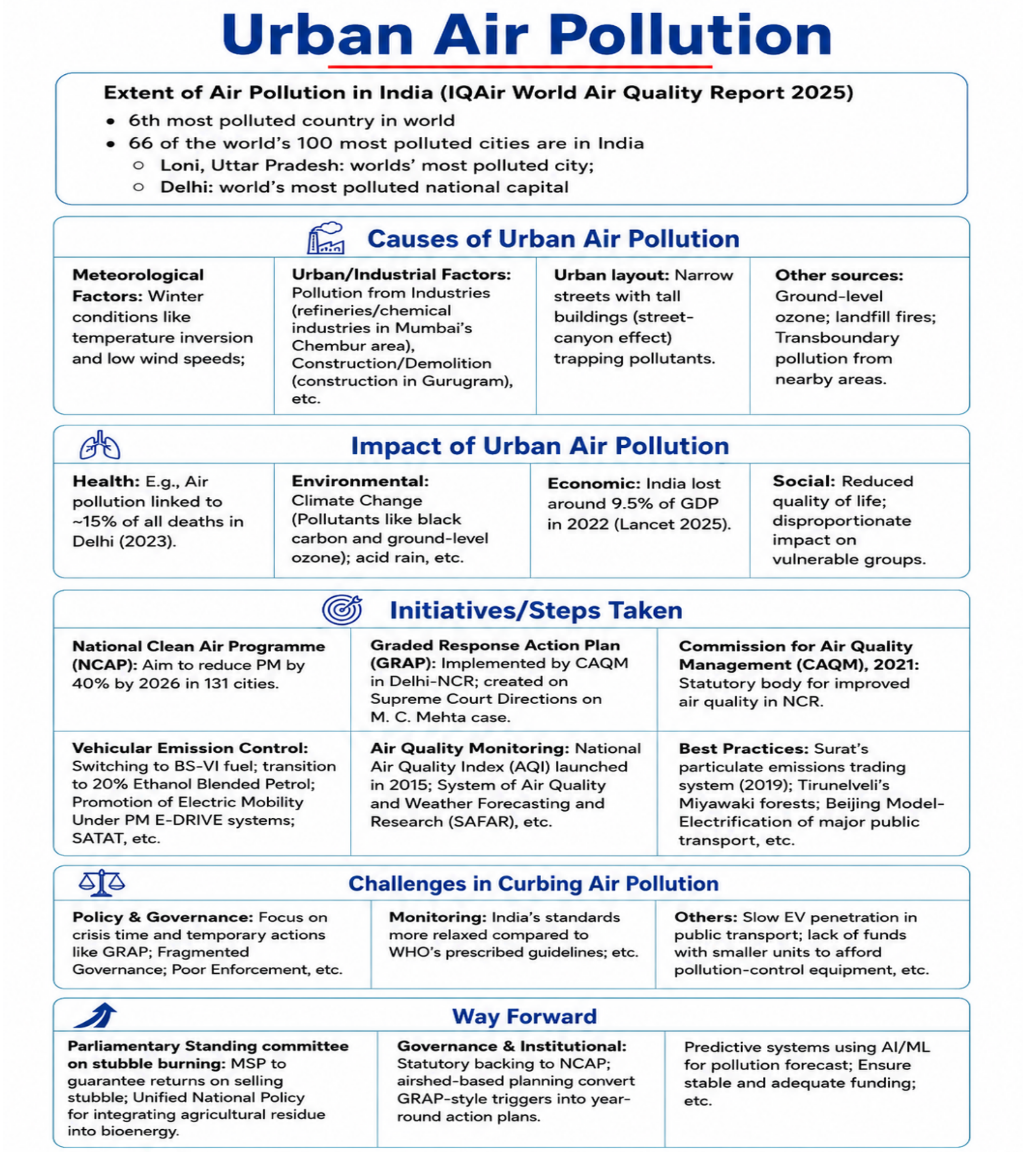
2. ENVIRONMENTAL POLLUTION AND DEGRADATION

2.1. AIR POLLUTION

2.1.1. URBAN AIR POLLUTION AT A GLANCE



Urban Air Pollution

Extent of Air Pollution in India (IQAir World Air Quality Report 2025)

- 6th most polluted country in world
- 66 of the world's 100 most polluted cities are in India
  - Loni, Uttar Pradesh: worlds' most polluted city;
  - Delhi: world's most polluted national capital

Causes of Urban Air Pollution

Meteorological Factors: Winter conditions like temperature inversion and low wind speeds;	**Urban/Industrial Factors:** Pollution from Industries (refineries/chemical industries in Mumbai's Chembur area), Construction/Demolition (construction in Gurugram), etc.	**Urban layout:** Narrow streets with tall buildings (street-canyon effect) trapping pollutants.	**Other sources:** Ground-level ozone; landfill fires; Transboundary pollution from nearby areas.

Impact of Urban Air Pollution

Health: E.g., Air pollution linked to ~15% of all deaths in Delhi (2023).	**Environmental:** Climate Change (Pollutants like black carbon and ground-level ozone); acid rain, etc.	**Economic:** India lost around 9.5% of GDP in 2022 (Lancet 2025).	**Social:** Reduced quality of life; disproportionate impact on vulnerable groups.

Initiatives/Steps Taken

National Clean Air Programme (NCAP): Aim to reduce PM by 40% by 2026 in 131 cities.	**Graded Response Action Plan (GRAP):** Implemented by CAQM in Delhi-NCR; created on Supreme Court Directions on M. C. Mehta case.	**Commission for Air Quality Management (CAQM), 2021:** Statutory body for improved air quality in NCR.
Vehicular Emission Control: Switching to BS-VI fuel; transition to 20% Ethanol Blended Petrol; Promotion of Electric Mobility Under PM E-DRIVE systems; SATAT, etc.	**Air Quality Monitoring:** National Air Quality Index (AQI) launched in 2015; System of Air Quality and Weather Forecasting and Research (SAFAR), etc.	**Best Practices:** Surat's particulate emissions trading system (2019); Tirunelveli's Miyawaki forests; Beijing Model- Electrification of major public transport, etc.

Challenges in Curbing Air Pollution

Policy & Governance: Focus on crisis time and temporary actions like GRAP; Fragmented Governance; Poor Enforcement, etc.	**Monitoring:** India's standards more relaxed compared to WHO's prescribed guidelines; etc.	**Others:** Slow EV penetration in public transport; lack of funds with smaller units to afford pollution-control equipment, etc.

Way Forward

Parliamentary Standing committee on stubble burning: MSP to guarantee returns on selling stubble; Unified National Policy for integrating agricultural residue into bioenergy.	**Governance & Institutional:** Statutory backing to NCAP; airshed-based planning convert GRAP-style triggers into year-round action plans.	Predictive systems using AI/ML for pollution forecast; Ensure stable and adequate funding; etc.

2.1.2. AIR POLLUTION IN DELHI- NCR

Why in the news?

CAQM invoked Stage-III of Graded Response Action Plan (GRAP) in NCR amid severe Air Pollution comprising a **ban on construction, mining, and polluting vehicles**.

About GRAP

- Emergency response mechanism based on Delhi's AQI level. Divided into four stages:
    - **Stage 1:** Poor category (AQI 201 to 300).
    - **Stage 2:** Very poor category (AQI 301-400).
    - **Stage 3:** Severe category (AQI 401-450).
    - **Stage 4:** Severe + category (AQI 451+).
- **Implementation: Commission for Air Quality Management** (**CAQM)** in NCR and adjoining areas**.**
    - CAQM was established under **Commission for Air Quality Management in NCR and Adjoining Areas Act, 2021.**
    - Replaced **Environment Pollution (Prevention and Control Authority).**

About National Air Quality Index (AQI)

- Launched by government in 2014 to **gauge air pollution levels** and communicate risks to public.
- There are six categories of AQI, namely 'Good' (0-50), 'Satisfactory' (51-100), 'Moderately polluted' (100-200), 'Poor' (201-300), 'Very Poor' (301-400), and 'Severe' (401-500).
- Eight pollutants (PM10, PM2.5, NO_2, SO_2, CO, O_3, NH_3, and Pb) are considered for calculating AQI.

Status of Delhi Pollution (as per CAQM Report on Causes of Air Pollution in Delhi-NCR)

- **Key contributors:** Secondary Particulate Matter (27%); Transport (23%); biomass burning (20%); dust (15%); **industry** including thermal power plants contributes **9%.**
- Around **two-thirds of Delhi's PM2.5** originates outside Delhi

Reason behind rising air pollution in Delhi during winters:

- **Wind Direction:** As monsoon withdraws, predominant wind direction changes to **north westerly** bringing dust from Rajasthan and sometimes from Pakistan & Afghanistan.
- **Temperature inversion:** Layer of cool air forms near ground, trapping pollutants and preventing them from dispersing.
- **Low wind speeds:** Reduce the dispersion of pollutants.
- **Other Factors: Stubble burning** in neighbouring states; weak monitoring of small and unorganised units, etc.

Recommendations (CAQM Report)

- Augment **waste-to-energy plants**, installing **barrier-free toll** systems and rationalize **Environment Compensation Charge.**
    - Environmental compensation is a policy instrument for the protection of the environment which works on the **Polluter Pay Principal.**
    - Supreme Court SC in Delhi Pollution Control Committee VS Lodhi Property co. ltd. case held that Pollution control boards (PCBs) can impose environmental compensation.
- **Phasing out polluting vehicles**, **expanding electric/CNG public transport and zero-emission mobility**, **etc**.
- **Implementing mandatory annual action plans** for NCR states to ensure accountability; shifting industries to cleaner fuels; curbing use of illegal fuels like pet coke, etc.

Conclusion

Beijing strategy involving **phased long term anti-pollution plans** coupled with **regional cooperation, investment and targeted source control** helped reduce its average to 92 (2024) from 144 (2015) which could be replicated in India.

2.1.3. CLOUD SEEDING

Why in the news?

Experts from IIT Kanpur successfully conducted a trial test on Cloud Seeding in Delhi, aimed at mitigating the city's severe air pollution.

About Cloud Seeding (or Artificial Rain)

- **Meaning: weather modification technique** aimed at enhancing precipitation from clouds.
- **Chemicals used**: Silver iodide, potassium iodide, and dry ice, which are dispersed into the sky via airplanes and helicopters.
    - These chemicals attract water vapour (acting as nuclei), helping form rain clouds.
- **Types: Hygroscopic Cloud Seeding** (accelerates the merging of droplets in liquid clouds) and **Glaciogenic Cloud Seeding** (induces ice formation in super cooled clouds).

Benefits

- **Reduces Air Pollution:** Can help clear pollutants and dust.
- **Enhances Rainfall in Drought-Prone Areas:** E.g. Dubai cloud seeding project.
- **Supports Agriculture:** Rain during dry spells, improving crop yields and farmer incomes.
- **Helps Regulate Weather Conditions:** Controls water vapor to reduce damage from hail, storms.
- **Other:** Wildfire mitigation, enhancing winter snowfall etc.

Concerns

- **Floods and Landslides**: Due to Excessive rain from cloud seeding.
- **Disturb Natural Weather Patterns**: It may disrupt natural weather cycles.
- **Lack of Reliable Information:** Lack of clarity on the financial costs involved.
- **Issues with Seeding Material:** Silver Iodide might be **toxic to terrestrial and aquatic life**, prompting exploration of less harmful alternatives.

Conclusion

Cloud seeding offers potential as a supplementary solution for **water scarcity** and agricultural support. However, its use must be guided by **scientific research, environmental safeguards**, and **clear regulations**.

2.2. WATER SCARCITY AND POLLUTION

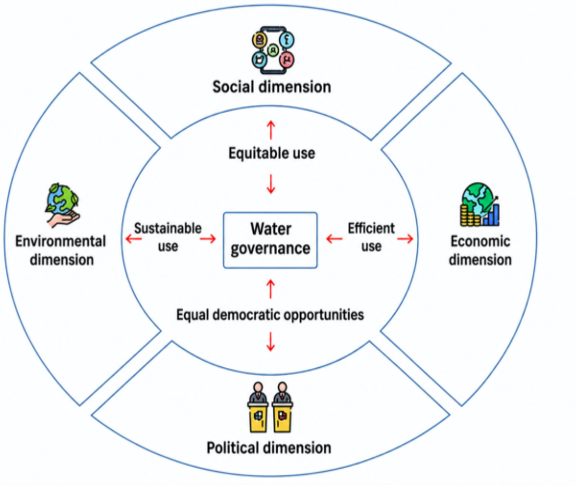
2.2.1. URBAN WATER GOVERNANCE

Why in the News?
The recent health crisis in Indore caused by contaminated municipal tap water have exposed the vulnerability of urban governance particularly, urban water systems.

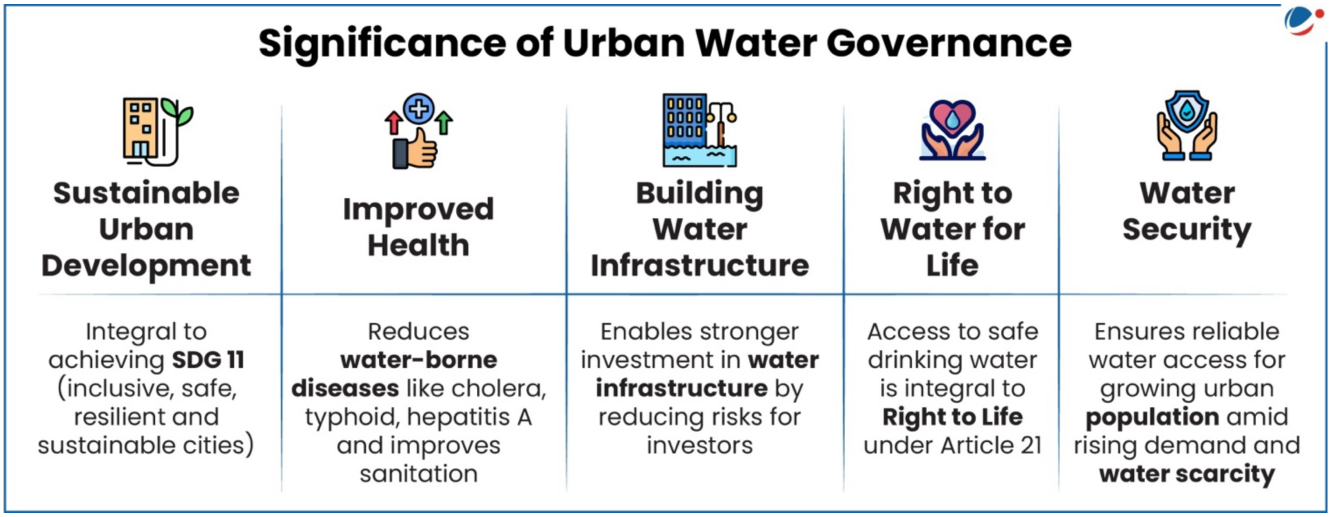
Water Governance in India

- **Constitutional status:** Water is a **State subject** under 7th schedule while Regulation and development of **Inter-State rivers** is a **Union Subject.**
    - **Article 262:** Parliament can provide for adjudication of inter-state river disputes.
    - At national level, **Ministry of Housing and Urban Affairs** oversees **urban water infrastructure**.
- **Legal framework:**
    - **Inter-State River Water Disputes (ISRWD) Act,1956** (constitution of Tribunals)

Dimensions of Water Governance



- **River Boards Act, 1956** (establishment of River Boards for regulating inter-state rivers)
- **Water (Prevention and Control of Pollution) Act, 1974**



Significance of Urban Water Governance

Sustainable Urban Development	Improved Health	Building Water Infrastructure	Right to Water for Life	Water Security
Integral to achieving **SDG 11** (inclusive, safe, resilient and sustainable cities)	Reduces **water-borne diseases** like cholera, typhoid, hepatitis A and improves sanitation	Enables stronger investment in **water infrastructure** by reducing risks for investors	Access to safe drinking water is integral to **Right to Life** under Article 21	Ensures reliable water access for growing urban **population** amid rising demand and **water scarcity**

Challenges associated with Urban Water Governance

- **Demand-Supply Imbalance:** India's water demand will double available supply by 2030 (NITI Aayog), while groundwater depletion could triple by 2041–2080.
- **Multiple agencies, overlapping jurisdictions:** E.g. Gurugram's PWD, Municipal Corporation, Gurugram Metropolitan Development Authority.
- **Inadequate Infrastructure**: ~ 38% of India's water supply lost as Non- Revenue Water (NRW i.e. treated water) through leakages, theft, unmetered usage, inaccurate billing.
- **Climate Vulnerability**: Erratic rainfall and droughts in cities. E.g. **Chennai (2019) and Bengaluru (2024) water crisis**.
- **Poor Wastewater Treatment**: Resulting in **pollution** and **reducing availability of safe water**. E.g. High level of pollutants in river Yamuna (New Delhi).
- **Groundwater dependence**: Intermittent piped supply drives reliance on borewells and tankers, causing aquifer depletion and water insecurity.

Initiatives taken for management of Urban Water Resources

- **Ministry of Jal Shakti (2019):** For Integrated approach and holistic planning**.**
- **Bureau of Indian Standards (BIS)** sets **drinking water quality standards (IS- 10500-2012)**.
  - As per BIS**, Water is unsafe** if bacteriologically contaminated (e.g., E. coli) or chemicals exceed limits **like fluoride (>1.5 mg/l), TDS (>2000 mg/l), arsenic (>0.05 mg/l), nitrates (>45 mg/l).**
- **Others:** Jal Jeevan Mission (JJM); Namami Gange; Atal Bhujal Yojana, **Varuni App** etc.
- **Best practices:**
  - **Mukhyamantri Jal Swavlamban Abhiyan (Rajasthan) based on "Four Waters Concept**" led to about a 4% rise in groundwater levels.

Way Forward

- **Recommendations of Standing Committee on Housing & Urban Affairs**
  - **Formulate National Urban Wastewater Reuse Policy** with enforceable benchmarks to achieve 100% treatment.
  - **Conduct long-term (25–30 year) national assessment of urban water needs**, factoring in population growth, migration, and climate resilience, to guide **National Urban Water Security Strategy**.
  - **Create Integrated Urban Water Management (IUWM) mechanism** at Centre and States to bridge demand–supply gaps through rainwater harvesting, wastewater reuse etc.

- **One water Approach:** E.g., Mihir Shah Committee recommended merging Central Water Commission (CWC) and the Central Ground Water Board (CGWB) to form a new National Water Commission (NWC).
- **Water Budgeting** can provide a systematic assessment that calculates water availability against demand within a defined geographical unit (village, watershed, block, etc.) to ensure balanced use.
  - NITI Aayog recently released a Report on Water Budgeting for Aspirational Blocks.
- **Promoting Behavioural change,** Community participation, Circular Water Economy and Gender-Responsive Water Governance. E.g., **Jan Bhagidari.**
- **Decentralised wastewater treatment technologies** for treating used water close to source, recovering over **95% of water with minimal land and energy use.**

Conclusion

India's approach to water governance built on the **foundation of conservation, sustainable use, and active community involvement** would strengthen efforts towards **water-secure future.**

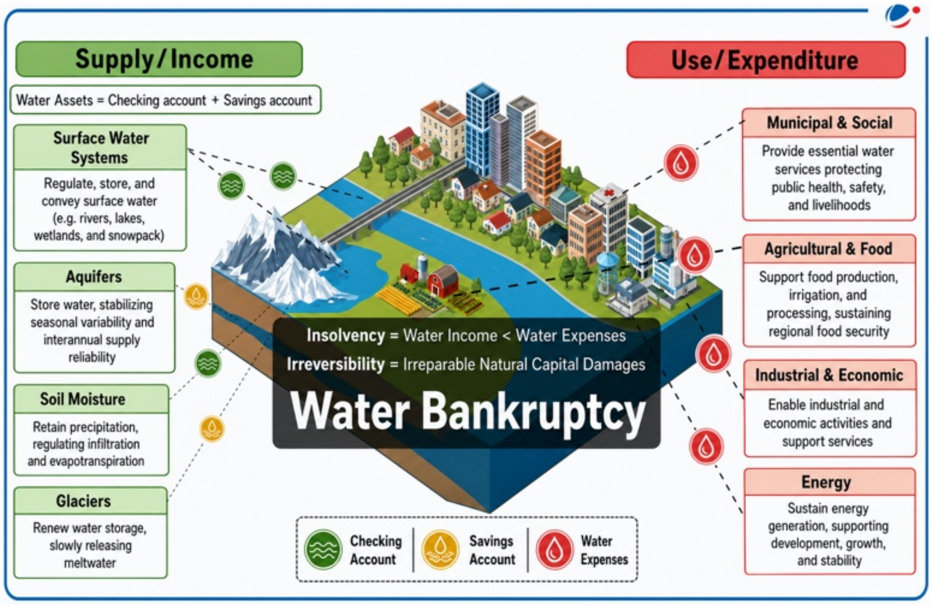
2.2.2. WATER BANKRUPTCY

Why in the news?

Recent UN University Institute for Water, Environment and Health's (UNU- INWEH) [academic arm of UN] report '**Global Water Bankruptcy'** declares that world has entered water bankruptcy state.

What is Water Bankruptcy?

- **Meaning:** Persistent **post-crisis condition** of human water system in which long term **water use has exceeded renewable freshwater inflows** and **safe depletion limits,** causing irreversible or effectively irreversible degradation.
- Resulting into **severe depletion of both 'checking accounts' and 'savings accounts'** of natural resource.
  - **Checking accounts** refer to **natural replenishment of rivers, wetlands, and reservoirs** over time.
  - **Savings accounts** refer primarily to **groundwater sources, including** glaciers, and aquifers, etc.


Supply/Income
Water Assets = Checking account + Savings account
Surface Water Systems
Regulate, store, and convey surface water (e.g. rivers, lakes, wetlands, and snowpack)
Aquifers
Store water, stabilizing seasonal variability and interannual supply reliability
Soil Moisture
Retain precipitation, regulating infiltration and evapotranspiration
Glaciers
Renew water storage, slowly releasing meltwater
Use/Expenditure
Municipal & Social
Provide essential water services protecting public health, safety, and livelihoods
Agricultural & Food
Support food production, irrigation, and processing, sustaining regional food security
Industrial & Economic
Enable industrial and economic activities and support services
Energy
Sustain energy generation, supporting development, growth, and stability
Insolvency = Water Income < Water Expenses
Irreversibility = Irreparable Natural Capital Damages
Water Bankruptcy
Checking Account
Savings Account
Water Expenses

- Water bankruptcy is the **outcome of both insolvency and irreversibility conditions**. (refer image)
- It is different from both Water stress and Water crisis.
  - **Water stress: High-water demand relative to supply**, largely reversible impact.

    Water crisis: Acute, time-bounded disruption often **triggered by a shock like** drought, flood, contamination, infrastructure failure that **temporarily push water systems beyond capacity** restored through emergency and restoration measures.

Reasons for Global Water Bankruptcy

- **Ecological liquidation:** Wetlands, floodplains, forests, and soils are converted or degraded in ways that increase short-term productive capacity while eroding long-term water storage, filtration, and buffering.

- **Slow-onset depletion**: Chronic overuse of surface and groundwater slowly degrades storage and quality, with early warning signs ignored until irreversible thresholds are crossed.
    - About 70% of world's major aquifers showing long-term declining trends.
- **Infrastructure overshoot**: Large-scale dams, diversions, expansion of cities, and industries, etc.
- **Climate-induced hydrological disruptions: Altering precipitation cycles**, increasing evapotranspiration, and **accelerating glacier and snowpack loss**.

Status of India's Water Crisis

- Despite holding 18% of the world's population, India has **only 4% of its freshwater resources**.
- **Average per capita water availability** is expected to **reduce 1140m^3 by 2050** (classified as water stress). (National Commission on Integrated Water Resources Development (NCIWRD) report)
- **70% of India's surface water is polluted**, though water remains recyclable if treated (NITI Aayog).

Recommendations of report for managing Water Bankruptcy

- **New Global Water Agenda needed**: Use **2026 and 2028 UN Water Conferences**, **2030 deadline for SDG 6** to globally recognize water bankruptcy, along with scaling up funds.
- **Recognize Global Water Bankruptcy explicitly**: Integrate into **Rio Conventions, SDG follow-up and review, UN-Water coordination**, etc.
- **Global Water Bankruptcy Monitoring**: Using Earth observation, satellite technologies, etc.
- **Water Diagnostics**: Support **national and basin-level assessments** to identify stress.
- **Others:** Transform water intensive sectors including agriculture and industry; address water-quality degradation, etc.

Conclusion

Water serves as a strategic opportunity in a fragmented world and acting early before stress **hardens into irreversible loss**, can **reduce shared risks, strengthen resilience, and rebuild trust through tangible results.**

2.2.3. TECHNOLOGY AND WATER MANAGEMENT

Why in the news?

Minister of State for Jal Shakti highlighted the role of modern technology for **Water Management and Conservation.**

Applications of Technology in Water Management and Conservation

- **AI-driven Analysis:** Uses GIS and satellite data for identify optimal locations for **farm ponds, recharge wells, and check dams** for rainwater harvesting and water budgeting.
- **Drones:** Surveying and creation of high-resolution maps, **perform automated inspections**, etc.
- **IoT Sensors and Smart Sensors:** Real-time monitoring of water quality, consumption patterns.
- **Micro-irrigation Systems: Drip and sprinkler irrigation** improves farm water-use efficiency and are key to **precision agriculture.**
- **Advanced Water Treatment Technologies: UV and membrane technologies (e.g., reverse osmosis, Membrane BioReactors)** are essential for recycling and reuse.
- **Blockchain Technology:** Secure, transparent, and efficient way to track water usage, distribution, and quality.

India's Tech Integration for Groundwater management

- **Geographic Information System (GIS):** helps in monitoring of minor irrigation projects.
- **Real Time Data Acquisition System (RTDAS):** installed for monitoring surface and ground water levels under **National Hydrology Project.**

- **India-Groundwater Resource Estimation System (IN-GRES)** developed by **Central Ground Water Board (CGWB)**
- **Satellite data** from platforms like **GRACE (Gravity Recovery and Climate Experiment)** for large-scale groundwater storage assessment.
- **Scientific River Management** deploying key technological tools **under National Mission for Clean Ganga (NMCG):**
  - **Geospatial river database** utilizing historical maps, high-resolution riverbed surveys, etc.
  - **Digital Twin model for Ganga Basin** to model the river management in real time.

Conclusion

Addressing emerging water challenges requires a **three-pronged approach of research, technological innovation and Jan Bhagidari.**

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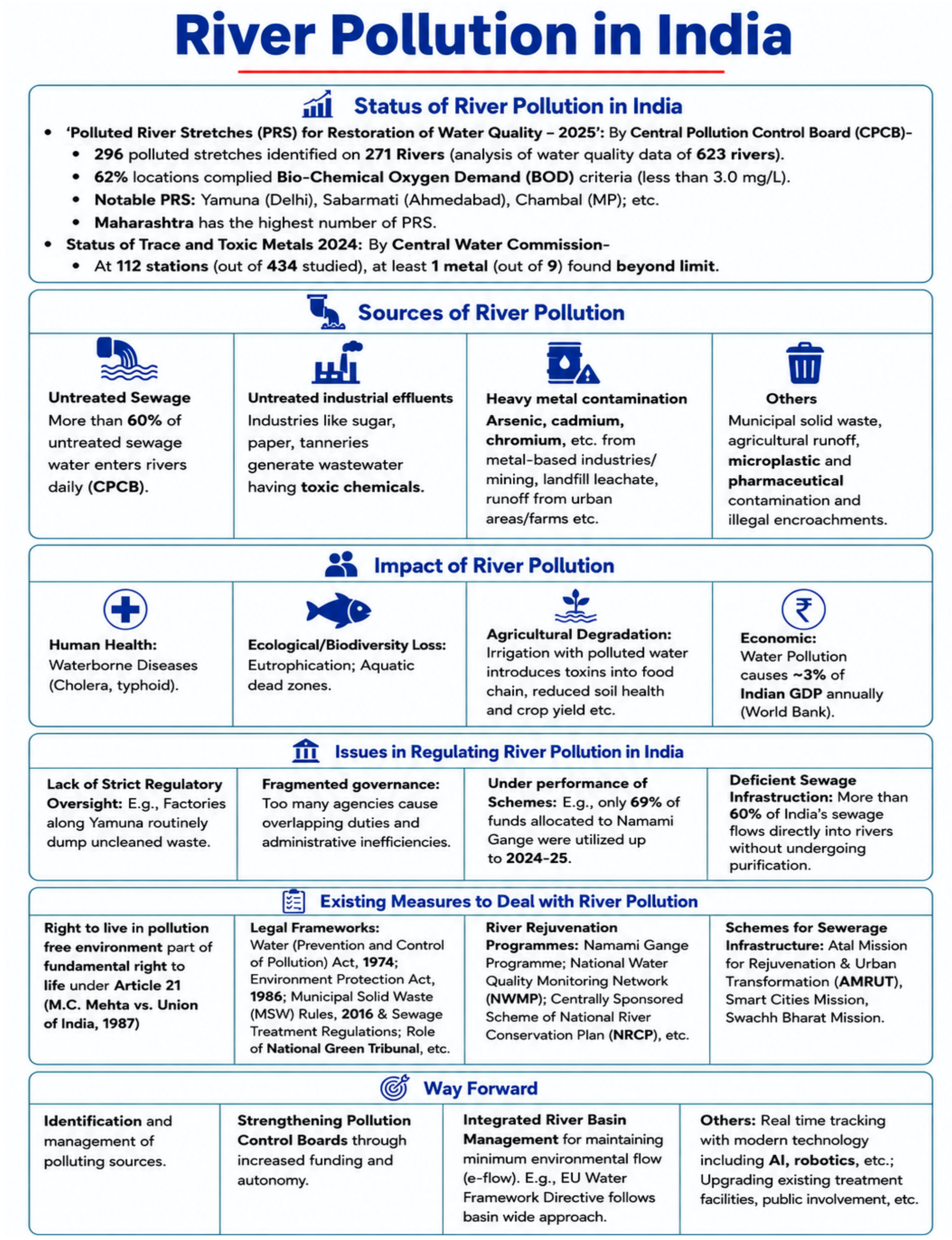
2.2.4. RIVER POLLUTION IN INDIA AT A GLANCE



River Pollution in India

Status of River Pollution in India

- **'Polluted River Stretches (PRS) for Restoration of Water Quality – 2025':** By **Central Pollution Control Board (CPCB)-**
  - **296** polluted stretches identified on **271 Rivers** (analysis of water quality data of **623 rivers**).
  - **62%** locations complied **Bio-Chemical Oxygen Demand (BOD)** criteria (less than 3.0 mg/L).
  - **Notable PRS:** Yamuna (Delhi), Sabarmati (Ahmedabad), Chambal (MP); etc.
  - **Maharashtra** has the highest number of PRS.
- **Status of Trace and Toxic Metals 2024:** By **Central Water Commission-**
  - At **112 stations** (out of **434** studied), at least **1 metal** (out of **9**) found **beyond limit.**

Sources of River Pollution

- **Untreated Sewage** More than **60%** of untreated sewage water enters rivers daily **(CPCB).**
- **Untreated industrial effluents** Industries like sugar, paper, tanneries generate wastewater having **toxic chemicals.**
- **Heavy metal contamination** **Arsenic, cadmium, chromium,** etc. from metal-based industries/ mining, landfill leachate, runoff from urban areas/farms etc.
- **Others** Municipal solid waste, agricultural runoff, **microplastic** and **pharmaceutical** contamination and illegal encroachments.

Impact of River Pollution

- **Human Health:** Waterborne Diseases (Cholera, typhoid).
- **Ecological/Biodiversity Loss:** Eutrophication; Aquatic dead zones.
- **Agricultural Degradation:** Irrigation with polluted water introduces toxins into food chain, reduced soil health and crop yield etc.
- **Economic:** Water Pollution causes **~3%** of **Indian GDP** annually (World Bank).

Issues in Regulating River Pollution in India

- **Lack of Strict Regulatory Oversight:** E.g., Factories along Yamuna routinely dump uncleaned waste.
- **Fragmented governance:** Too many agencies cause overlapping duties and administrative inefficiencies.
- **Under performance of Schemes:** E.g., only **69%** of funds allocated to Namami Gange were utilized up to **2024-25.**
- **Deficient Sewage Infrastruction:** More than **60%** of India's sewage flows directly into rivers without undergoing purification.

Existing Measures to Deal with River Pollution

- **Right to live in pollution free environment** part of **fundamental right** to life under **Article 21 (M.C. Mehta vs. Union of India, 1987)**
- **Legal Frameworks:** Water (Prevention and Control of Pollution) Act, **1974**; Environment Protection Act, **1986**; Municipal Solid Waste (MSW) Rules, **2016** & Sewage Treatment Regulations; Role of **National Green Tribunal**, etc.
- **River Rejuvenation Programmes:** Namami Gange Programme; National Water Quality Monitoring Network **(NWMP)**; Centrally Sponsored Scheme of National River Conservation Plan **(NRCP)**, etc.
- **Schemes for Sewerage Infrastructure:** Atal Mission for Rejuvenation & Urban Transformation **(AMRUT)**, Smart Cities Mission, Swachh Bharat Mission.

Way Forward

- **Identification** and management of polluting sources.
- **Strengthening Pollution Control Boards** through increased funding and autonomy.
- **Integrated River Basin Management** for maintaining minimum environmental flow (e-flow). E.g., EU Water Framework Directive follows basin wide approach.
- **Others:** Real time tracking with modern technology including **AI, robotics,** etc.; Upgrading existing treatment facilities, public involvement, etc.

2.2.5. GROUNDWATER EXTRACTION IN INDIA

Why in the News?

Central Ground Water Board (CGWB) and States/UTs jointly published **National Compilation on Dynamic GW Resources of India 2025.**

Status of Ground Water Extraction (GWE) in India

- **Total Annual Ground Water Extraction (2025):** Marginally increased to 247.22 BCM.
- **Extent of ground water exploitation as** % units out of **total 6762 assessment units:**
    - **Over-exploited (**GWE exceeding annually replenishable ground water recharge): 10.8% (significant decline from 17.24% in 2017)
    - **Critical** (90–100% GWE of annual extractable resources available): 2.97%
    - **Semi-critical (**70–90% GWE of annual extractable resources available): 11.2%
    - **Safe** (GWE<70%): 73.2% (improvement from 62.6% in 2017)
    - **Saline** (Predominantly brackish or saline groundwater; unfit for most uses): 1.8%
- **States/UTs with >25% Over-exploited, Critical, and Semi-Critical units:** Haryana, Karnataka, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Delhi, and Puducherry.

GW Resources of India: Current Scenario

- India is **World's Largest consumer of GW (~ 25%** of total global extraction).
- **Sectoral Usage: 87%** groundwater extracted used in **agricultural sector, 11%** in **domestic sector.** (Annual Ground Water Quality Report 2024)

Reasons for High GW extraction

- **Urbanization and Aquifer Desaturation:** Due to rapid urbanization leading to sealing of recharge areas and destruction of traditional water bodies.
- **Institutional Gaps:** Outdated laws (1882 Indian Easement Act), auditing gaps cause over-extraction.
- **Climate Change**: Study projects **tripling of groundwater depletion rates by 2080** primarily driven by Climate-induced intensification.
- **Land subsidence**: Study found land subsidence in five megacities of **Delhi (National Capital Territory, NCT), Mumbai, Kolkata, Bengaluru** and **Chennai** due to excessive groundwater extraction.

Government Conservation Initiatives

- **India Groundwater Resource Estimation System:** GIS based platform.
- **Atal Bhujal Yojana:** Community participation for sustainable GW Management.
- **National Aquifer Mapping and Management Programme.**
- **Master Plan for Artificial Recharge, 2020.**
- **Others:** Jal Shakti Abhiyan, Jal Sanchay Jan Bhagidari, Mission Amrit Sarovar, Bhu-Neer Portal by CGWA, etc.

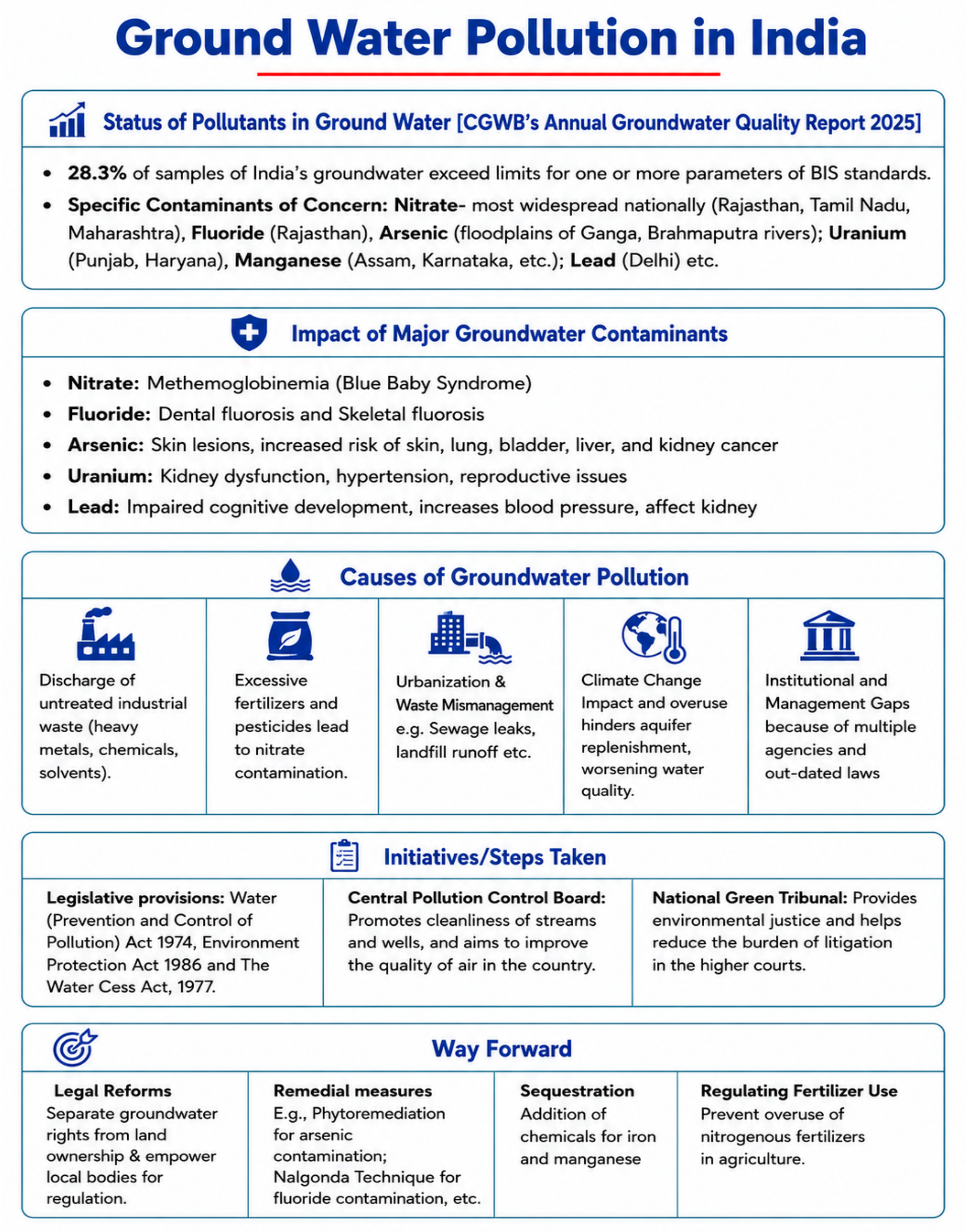
Way Forward

- Create **National Water Commission (NWC)** by merging CWC & CGWB (Mihir Shah Committee).
- **Formalize GW rights** to empower marginalized communities and farmer.
- **Promote Sustainable Water Practices** like Water Efficient Agriculture **(**Crop diversification, precision agriculture); **Rainwater Harvesting (**E.g. Rajasthan's Johad), Blue-Green Infrastructure, etc.
- **Others:** Aquifer-based Planning; **Community Empowerment E.g.** Telangana's Mission Kakatiya etc.

Conclusion

Findings of the report though help in improved **planning and management also** highlights heavy metal pollution and aquifer depletion requiring targeted approach for **water safety and accessibility.**

2.2.6. GROUNDWATER POLLUTION IN INDIA



Ground Water Pollution in India

Status of Pollutants in Ground Water [CGWB's Annual Groundwater Quality Report 2025]

- **28.3%** of samples of India's groundwater exceed limits for one or more parameters of BIS standards.
- **Specific Contaminants of Concern: Nitrate**- most widespread nationally (Rajasthan, Tamil Nadu, Maharashtra), **Fluoride** (Rajasthan), **Arsenic** (floodplains of Ganga, Brahmaputra rivers); **Uranium** (Punjab, Haryana), **Manganese** (Assam, Karnataka, etc.); **Lead** (Delhi) etc.

Impact of Major Groundwater Contaminants

- **Nitrate:** Methemoglobinemia (Blue Baby Syndrome)
- **Fluoride:** Dental fluorosis and Skeletal fluorosis
- **Arsenic:** Skin lesions, increased risk of skin, lung, bladder, liver, and kidney cancer
- **Uranium:** Kidney dysfunction, hypertension, reproductive issues
- **Lead:** Impaired cognitive development, increases blood pressure, affect kidney

Causes of Groundwater Pollution

Discharge of untreated industrial waste (heavy metals, chemicals, solvents).	Excessive fertilizers and pesticides lead to nitrate contamination.	Urbanization & Waste Mismanagement e.g. Sewage leaks, landfill runoff etc.	Climate Change Impact and overuse hinders aquifer replenishment, worsening water quality.	Institutional and Management Gaps because of multiple agencies and out-dated laws

Initiatives/Steps Taken

Legislative provisions: Water (Prevention and Control of Pollution) Act 1974, Environment Protection Act 1986 and The Water Cess Act, 1977.	**Central Pollution Control Board:** Promotes cleanliness of streams and wells, and aims to improve the quality of air in the country.	**National Green Tribunal:** Provides environmental justice and helps reduce the burden of litigation in the higher courts.

Way Forward

Legal Reforms	**Remedial measures**	**Sequestration**	**Regulating Fertilizer Use**
Separate groundwater rights from land ownership & empower local bodies for regulation.	E.g., Phytoremediation for arsenic contamination; Nalgonda Technique for fluoride contamination, etc.	Addition of chemicals for iron and manganese	Prevent overuse of nitrogenous fertilizers in agriculture.

2.3. OTHER TYPES OF POLLUTION/DEGRADATION

2.3.1. SOLID WASTE MANAGEMENT (SWM) RULES, 2026

Why in the News?

Union Ministry of Environment, Forest, and Climate Change notified **SWM Rules, 2026**, superseding **SWM Rules, 2016.**

About Solid Waste Management (SWM) Rules, 2026

- **Notified under: Environment (Protection) Act, 1986,** (effective from April 1, 2026).
- Rules integrate principles of **Circular Economy** and **Extended Producer Responsibility (EPR).**
- **Mandatory Four-stream Segregation of Solid Waste at Source.**
- **Definition of Bulk Waste Generators (BWGs):** Includes entities like government departments, local bodies, residential societies etc. with responsibilities to-
  - Process wet waste on-site where possible, or obtain **Extended Bulk Waste Generator Responsibility (EBWGR) certificate**.
- **Centralised Online Portal:** To track all stages of SWM.
- **Use of Refuse Derived Fuel (RDF) by Industries: By cement** plants and **waste-to-energy** plants.
  - RDF is produced by shredding/dehydrating municipal solid waste with high calorific value.
- **Mandatory Annual audits of landfills**: Mapping and assessment of all **legacy waste dumpsites**
- **Hilly Areas and Islands:** Local bodies can levy user fees on tourists.
- **Environmental Compensation (EC): 'Polluter Pays' principle** for non-compliance.

Four-Stream Segregation of Solid Waste

Mandatory Under SWM Rules, 2026

Wet Waste

Kitchen waste, vegetables, fruit peels, meat, flowers

➜ Composted or processed through bio-methanation at nearest facility

Dry Waste

Plastic, paper, metal, glass, wood, rubber

➜ Transported to Material Recovery Facilities (MRFs) for sorting and recycling

Sanitary Waste

Used diapers, sanitary towels, tampons, condoms.

➜ Securely wrapped and stored separately

Special Care Waste

Paint cans, bulbs, mercury thermometers, medicines

➜ Collected by authorised agencies or deposited at designated collection centres

Segregate at Source

Proper waste segregation helps in effective recycling, reduces landfill burden, and protects the environment

Status of SWM in India

- **Type: ~55-60%** is **biodegradable** waste; **15-20%** is **recyclable; 15-25%** is **hazardous or non-recyclable** waste.
- **60% of total waste generation** is from Urban areas.
- **2.56% share** of Waste sector **in India's Total emissions** in 2020 (India's 4th Biennial Update Report).

Challenges in Solid Waste Management

- **Total waste generation projected to increase** to **165 million tonnes by 2030** and **436 million tonnes by 2050.**
- Only **60-70%** of waste is **collected,** and merely **15-20%** is **processed** due to poor coordination among multiple stakeholders and inconsistent waste segregation at source.
- **Weak enforcement mechanisms, poor accountability** in waste tracking, and implementation gaps in **Extended Producer Responsibility (EPR)**.
- **Other challenges: Rag-pickers working in informalized sector; Limited financial viability** of waste processing enterprises and **underdeveloped recycling markets;** widespread public **complacency**; growing legacy waste; limited R&D, etc.

Existing Legal Framework for SWM

- **Solid Waste Management Rules, 2016**
- **Plastic Waste Management Rules, 2016**
- **E-Waste Management Rules 2022**
- **Environment (Construction and Demolition) Waste Management Rules,** 2025 came into effect from April 1, 2026.
- **Bio-Medical Waste Management Rules, 2016**
- **Environment Protection (Management of Contaminated Sites) Rules, 2025:** Covers 189 hazardous substances.

Key Initiatives for SWM in India

- **Swachh Bharat Mission Urban (SBM 2.0):** To make all cities **garbage-free by 2026.**
- **Dumpsite Remediation Accelerator Programme (DRAP)**
- **City Investments to Innovate, Integrate and Sustain 2.0 (CITIIS 2.0)**
- **GoBARDHAN (Galvanizing Organic Bio-Agro Resources Dhan)**

Way Forward

- **Invest in decentralized processing facilities**, establish material recovery facilities (MRFs) in all cities, etc.
- **Deploy digital tracking systems** with GPS and RFID, AI, etc.
- **Develop Markets for Recyclables**, e.g. **eco-industrial parks** focused on recycling industries.
- **Address Legacy Waste,** e.g., Dumpsite Remediation Accelerator Programme (DRAP) under **Swachh Bharat Mission-Urban 2.0** aims at covering **~8.8 crore MT of legacy waste.**
- **Others:** Strengthen regulatory Framework; Institutional coordination by establishing dedicated waste management cells in ULBs; financial sustainability (green financing and climate funds), etc.
- **Learning from Best Practices:**
    - **Indore Model** (100% door-to-door waste collection through public engagement);
    - **Anupam Model (New Delhi)** [residential colonies with successful decentralised waste management];
    - **SWaCH (Solid Waste Collection & Handling) Pune Model** for door-to-door waste collection.

Conclusion

Strengthening **urban governance, and promoting sustainable waste practices** will make waste sector a critical enabler of India's long-term goals of advancing Net Zero 2070 goals.

2.3.2. PLASTIC POLLUTION

Why in the News?

Plastic Waste Management (Amendment) Rules, 2026 aiming to amend **Plastic Waste Management Rules 2016** under **Environment (Protection) Act, 1986** were notified.

Key Changes in 2026 Amendment Rules

- **Producers, importers, and brand owners mandated to** use **higher amounts of recycled plastic in packaging (e.g.**, Category I targets scale from 30% in 2025-26 to 60% from 2028-29 onwards).
    - **Exemptions** if **statutory bodies (like FSSAI) prohibit recycled plastic**.
    - Unfulfilled 2025-26 targets for **food contact applications to** be **carried forward for up to 3 years**.
- **Explicitly defines terms** like "**end of life disposal**," "**reuse**," and "**Plastic Waste Processors**" to remove regulatory ambiguities.
- Recycled packaging to conform to **Indian Standard IS 14534:2023**.
- **Decentralised enforcement by Urban Local Bodies (ULBs).**
- **Significance of rules: Promotes recycling** and circular economy**;** reduces plastic in **terrestrial and marine ecosystems**; minimizes health risks, and strengthens EPR, etc.

About Plastic Pollution

- **Extent:** >**460 million metric tons of plastic are produced every year**, and ~20 million end up polluting the environment. (World Economic Forum)
- **Source:** Largely from **single-use products** (bottles, caps, cigarettes, shopping bags, cups, straws, etc.). [IUCN]
- **Rising Global production/Trade:** Mainly for single use, Grew from **2 million metric tonnes (MMT)** in **1950** to **436 MMT** in **2022. (UNCTAD).**

Other measures to control Plastic Pollution

- **Solid Waste Management Rules, 2016**
- **Plastic Waste Management (PWM) Rules, 2016 and its amendments**: Extended Producer Responsibility (PWM (Second Amendment) Rules, 2022); Raised thickness limit of **120 microns,** Ban on single use plastic items (PWM (Amendment) Rules, 2021) etc.
- **Others**: Mandatory Jute Packaging Act, 2010, National Dashboard on Elimination of Single Use Plastics, National Circular Economy Framework (2024) by CII, etc.
- **Global Initiatives**: MARPOL; RIO+20 Declaration; Basel Convention Amendments; etc.

Key Issues with Plastic Pollution management

- **Absence of International Agreements: Intergovernmental Negotiating Committee** (INC) talks to develop **global plastic pollution treaty adjourned without consensus** on key issues.
- **Untapped Potential: Bio based** and **Compostable Plastics** constitute only **1.5% of global plastic production.**
- **Policy Issues: Tariffs** on **plastic and rubber products** reduced from **34% to 7.2%**, same for **alternatives** like bamboo, etc., **remains around 14.4%.**
- **Human Health:** Plastics emit **gases and pollutants**; Microplastics and nano plastics show early evidence of cell damage and immune response.
- **Compounding Pollution:** Rising **Stratospheric ozone depletion, Photochemical smog,** etc.

Way Forward

- **Sector Based Reforms:** E.g., **tackling single use plastics** through targeted bans like taxes and **plastics with long life span** (E.g., road construction) through better R&D, and product design.
- **Strengthen Plastic Data Systems:** To improve **transparency** and **comparability** across its life cycle.
- **Synergies with related Frameworks:** Like **Basel, Rotterdam, and Stockholm (BRS)** Conventions.

Conclusion

Global Plastic Treaty could be a **turning point in translating global intent into tangible outcomes** by aligning with the **principles of sustainable production and consumption.**

2.3.3. E-WASTE MANAGEMENT IN INDIA

Why in the news?

At the Paryavaran NITI Manthan, policymakers flagged gaps in Extended Producer Responsibility (EPR) implementation as India loses recoverable e-waste materials worth nearly ₹51,000 crore.

Status of India's E-Waste

- India is **3rd largest e-waste** generator globally.
- **E-waste generation increased** from ~2.76 MMT (2020) to ~6.19 MMT (2024)
- Projected to reach 14 MMT by 2030.

Issues related to E-Waste Management in India

- **Weak Enforcement:** Allows spurious and non-operational recyclers to distort EPR markets through fraudulent certification.
- **Informalization:** India's formal recycling rate is 10%, compared to global average (~22%), and USA (56%).
- **Narrow focus**: EPR coverage in E-waste recycling is limited to Gold, Copper, Iron, and Aluminium.
- **Other issues:** Low skills; accessibility of advanced recycling processes; collection inefficiencies; low consumer awareness etc.

Government Measures for E-waste management

- **E-Waste (Management) Rules, 2022**: Strengthened EPR framework for producers and recyclers.
  - **EPR E-Waste portal & Trading Platform**: Developed by CPCB for registration, tracking and monitoring of e-waste, along with EPR certificate trading mechanisms.
- **Battery Waste Management Rules (BWMR), 2022**: Mandates collection, recycling, and refurbishment targets, prohibiting landfill disposal and incineration.
- **National Critical Mineral Mission (NCMM)**: Aims to develop domestic recycling capacity for critical minerals from lithium-ion batteries, e-waste and industrial scrap.

Way Forward

- **GST-linked verification:** To improve traceability and reduce discrepancies in recycling claims.
- **Expanding EPR coverage:** To other high-value metals and critical minerals.
- **Promote Advanced Recycling Technologies:** Like hydrometallurgy, AI-based material recovery systems etc.
- **Other measures:** Increase authorised collection centres; integrate informal workers through training, certification and financial incentives; etc.

Conclusion

Moving from a 'waste economy' to a 'circular economy' is essential to unlock the economic and strategic value embedded in India's growing e-waste stream.

2.4. KEYWORDS

Urban Air Pollution	National Air Quality Index (AQI)	Water Governance	Water Bankruptcy
Graded Response Action Plan (GRAP)	Heavy metal contamination	Ground Water Extraction	Aquifer Desaturation
Cloud Seeding	E-waste	Polluter Pay Principal	Extended Producer Responsibility (EPR)

2.5. PRACTICE QUESTION

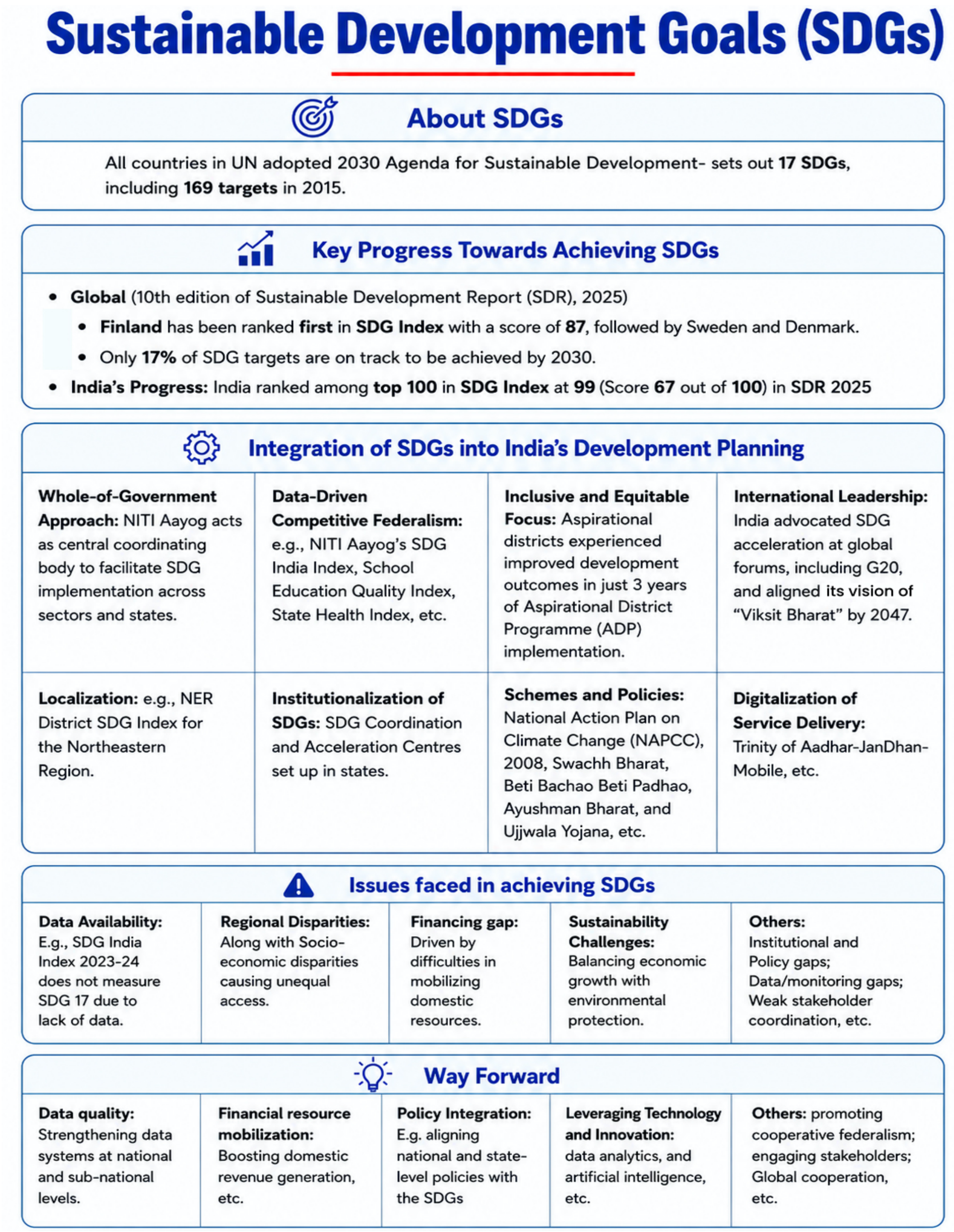
Examine the factors responsible for depleting groundwater in India. What are the steps taken by the government to mitigate such depletion of groundwater? (GS-III 2025, 15 Marks)

Introduction	Body Part 1	Body Part 2	Conclusion
Highlight the Ground Water (GW) Depletion Data from the Dynamic GW Resources of India 2025 Report.	Mention the key factors responsible for the depletion of GW in India.	Suggest Various Conservation Initiatives taken by the Government.	Conclude by suggesting certain state level best practices.

3. SUSTAINABLE DEVELOPMENT

3.1. SUSTAINABLE DEVELOPMENT GOALS (SDGS)

3.1.1. SUSTAINABLE DEVELOPMENT GOALS (SDGS) AT A GLANCE



Sustainable Development Goals (SDGs)

About SDGs

All countries in UN adopted 2030 Agenda for Sustainable Development- sets out **17 SDGs**, including **169 targets** in 2015.

Key Progress Towards Achieving SDGs

- **Global** (10th edition of Sustainable Development Report (SDR), 2025)
  - **Finland** has been ranked **first** in **SDG Index** with a score of **87**, followed by Sweden and Denmark.
  - Only **17%** of SDG targets are on track to be achieved by 2030.
- **India's Progress:** India ranked among **top 100** in **SDG Index** at **99** (Score **67** out of **100**) in **SDR 2025**

Integration of SDGs into India's Development Planning

Whole-of-Government Approach: NITI Aayog acts as central coordinating body to facilitate SDG implementation across sectors and states.	**Data-Driven Competitive Federalism:** e.g., NITI Aayog's SDG India Index, School Education Quality Index, State Health Index, etc.	**Inclusive and Equitable Focus:** Aspirational districts experienced improved development outcomes in just 3 years of Aspirational District Programme (ADP) implementation.	**International Leadership:** India advocated SDG acceleration at global forums, including G20, and aligned its vision of "Viksit Bharat" by 2047.
Localization: e.g., NER District SDG Index for the Northeastern Region.	**Institutionalization of SDGs:** SDG Coordination and Acceleration Centres set up in states.	**Schemes and Policies:** National Action Plan on Climate Change (NAPCC), 2008, Swachh Bharat, Beti Bachao Beti Padhao, Ayushman Bharat, and Ujjwala Yojana, etc.	**Digitalization of Service Delivery:** Trinity of Aadhar-JanDhan-Mobile, etc.

Issues faced in achieving SDGs

Data Availability: E.g., SDG India Index 2023-24 does not measure SDG 17 due to lack of data.	**Regional Disparities:** Along with Socio-economic disparities causing unequal access.	**Financing gap:** Driven by difficulties in mobilizing domestic resources.	**Sustainability Challenges:** Balancing economic growth with environmental protection.	**Others:** Institutional and Policy gaps; Data/monitoring gaps; Weak stakeholder coordination, etc.

Way Forward

Data quality: Strengthening data systems at national and sub-national levels.	**Financial resource mobilization:** Boosting domestic revenue generation, etc.	**Policy Integration:** E.g. aligning national and state-level policies with the SDGs	**Leveraging Technology and Innovation:** data analytics, and artificial intelligence, etc.	**Others:** promoting cooperative federalism; engaging stakeholders; Global cooperation, etc.

3.1.2. FINANCING FOR SUSTAINABLE DEVELOPMENT

Why in the News?

4th International Conference on Financing for Development (FFD4) adopted final outcome document **Compromiso de Sevilla** (**Sevilla Commitment),** to address developing countries' SDG financing gap.

More on News

- **Sevilla Commitment** is adopted by **consensus,** to close **$4 trillion annual SDG financing gap in developing countries.**
- Indian Finance Minister also proposed a **Seven-point strategy to boost private investment** at FFD4.
    - Strengthening multilateral banks, improving credit rating methods, and developing domestic financial markets, Unlocking capital at Grassroots Level, scaling blending financing, etc.

Evolution of Financing for Sustainable Development

Monterrey Consensus (2002)

- Marked beginning of **Financing for Development process at United Nations**
- It focused on increased **Official Development Assistance (ODA),** aid effectiveness (Paris Declaration), Governance Reforms (E.g. in IMF) and innovative financing mechanisms.

Doha Declaration (2008)

- It reaffirmed Monterrey Consensus **amid financial crisis of 2008.**
- It added new understandings to financing based on **gender and environment** (laid the foundation for **Green Climate Fund).**

Addis Ababa Action Agenda (2015)

- It introduced new financing frameworks for sustainable development such **as Integrated National Financing Frameworks (INFFs),** Technology Bank for Least Developed Countries etc.
- It set the stage for future initiatives **by reinforcing the 2030 Agenda commitment**

Requirement for Financing for Sustainable Development

- **SDG Financing Gap:** It has reached **4 trillion US dollars annually** (UN estimates).
- **Climate Finance Investment**: In enhanced NDCs scenario, energy-related investment is expected to grow by **40% between 2022- 2030 (OECD,2025).**
- **Wealth Inequality:** Wealthiest 1% own more wealth than 95% of total global population combined**. (Oxfam 2024)**
- **Debt Trap**: Over 40% of people living in extreme poverty live in countries with severe debt challenges. **{Financing for Sustainable Development Report (FSDR) 2023}.**

Impediments to Financing for Sustainable Development

- **Shrinking Fiscal Space:** 46 developing countries (3.4 billion people) spend more on interest payments than on either health or education. **(UNCTAD)**
- **Unequal Special Drawing Rights (SDR) Allocation:** E.g. of total SDR allocations, developed countries receive 66% while least developed countries receive just 2.5%. (FSDR Report,2023).
- **Geo-economic Fragmentation: E.g.** >24000 new restrictions imposed on trade and investment between 2020 to 2024 **(Economic Survey 2024-25).**
- **Illicit financial flows:** Reduces availability of resources for **financing SDGs**.
- **Tax Disparity:** E.g. Wealth of richest 1% has **surged $33.9 trillion since 2015** enough to **end annual poverty 22 times** yet billionaires only pay **around 0.3% in real taxes**. **(Oxfam 2025)**

Steps to be Taken (New Financing Announced under Seville Commitment)

- **To address debt challenge:**
    - Debt for Development swap programme (**E.g., Italy** will convert 230 million Euros of debt obligations of African countries into investments in development projects)

  - **Debt "Pause Clause" Alliance:** To suspend debt service payments during crises.
  - **Debt Swaps for Development Hub** (led by Spain and the World Bank)
  - **Sevilla Forum on Debt**: Help countries learn from one another and coordinate their approaches in debt management and restructuring.
- **To catalyse investment with development impact**
  - **Scaling Blended Finance: E.g. Blended finance platform, SCALED** has been launched
  - An **Effective Taxation of High-Net-Worth Individuals initiative (led by Brazil and Spain)**
- **To support architecture reform at the national and global levels**
  - **Enhancing Local Currency Lending:** E.g. FX EDGE Toolbox (Inter-American Development Bank) and Delta Liquidity Platform (European Bank for Reconstruction and Development), etc.
  - **Coalition led by UK and Bridgetown Initiative:** Scale-up pre-arranged financing from 2% to 20% of total disaster financing by 2035.

Conclusion

Creating the right environment for **private investment, strengthening public development banks, and reforming the multilateral system** are essential to align finance with the SDGs.

3.1.3. LOCALISATION OF SUSTAINABLE DEVELOPMENT GOALS (SDGS)

Why in the news?

NITI Aayog released the District SDG (Sustainable Development Goals) Index 2023–24 for North East Region (NER) ranking **Hnahthial (Mizoram)** as the best **performing district.**

Significance of Localising the SDG Goals

- **Local spaces as key site of Delivery:** State-level **Vision and Agenda documents** set targets for implementation and monitor through **Village Level Monitoring Committee** like that in Mizoram.
- **Bottom-Up Approach:** Subnational governments act as **bridge** between National government and communities fostering civil society, academia and private sector participation.
- **Mobilizing Local resources:** By adopting measures **to align state budgets** with SDGs.
- **Address Disparities:** Local achievements to **intra-regional** and **inter-district disparities** and align it with **national average.**

Key Challenges with SDG Localisation

- **Financial Constraints: Competing priorities** in municipal budgets, where essential services like healthcare and education may take **precedence over sustainability projects.**
- **Intersectionality of Goals:** Local governments may struggle to **balance economic growth** with **environmental sustainability.**
- **Data Quality and Availability:** Lack of **up-to-date socio-economic data** hampers evidence-based decision-making.

India and SDG Localisation

- **NITI Aayog:** Cooperative and Competitive federalism, SDG India Index, Agenda 2030, etc.
- **Initiatives/Schemes: Panchayat Advancement Index (PAI),** Central Schemes like **Rashtriya Gram Swaraj Abhiyan (RGSA), Pradhan Mantri Awas Yojana** and State Schemes like CM's **Samagra Gramya Unnayan Yojana (Assam), etc.**

Conclusion

Strengthening **local governance** and using **innovative financial mechanism** can help adapt strategies **fitting unique socio-economic** and **cultural landscapes** promoting SDG Localisation.

3.1.4. SUSTAINABLE DEVELOPMENT AND PEOPLE'S NEEDS

Why in the News?

Uttarakhand Government granted in-principle approval to **Netala bypass in Bhagirathi Eco-sensitive Zone,** despite earlier rejections by Supreme Court's high-powered committee over ecological and social concerns, indicating potential conflict.

About Eco-sensitive Zone

- **Ecologically important and fragile areas** around protected areas.
- Notified by **central government** under **Environment (Protection) Act, 1986.**
- **ESZ Guidelines classify activities under three categories:**
    - **Prohibited:** Commercial Mining, setting of industries causing pollution, etc.
    - **Regulated:** Felling of Trees, Establishment of hotels and resorts, etc.
    - **Permitted:** Ongoing agriculture and horticulture practices by local communities, etc.

Why is there conflict between Sustainable Development and People's needs?

- **Economic Dependence on Natural Resources**: E.g., Tribals, pastoralists, small farmers, small businesses offering job opportunities, etc.
- **Displacement**: >40% of tribals population is being displaced by developmental activities.
- **Protection to national interest: Van (Sanrakshan Evam Samvardhan) Amendment Rules, 2025,** provide special dispensation to critical minerals for compensatory afforestation.
- **Policy and Governance Gaps**: Top down decision making; weak social safety net, etc.
- **Costly solutions:** Limited access to clean tech (solar pumps, etc); credit constraints, etc.

Initiatives taken by Government to reduce conflict

- **Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (RFCTLARR) Act, 2013**: Act mandates **Social Impact Assessment.**
- **Environmental Impact Assessment (EIA):** Under **Environment (Protection) Act, 1986.**
- **Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006.**
- **Compensatory Afforestation Fund Act (2016).**
- **District Mineral Foundation (DMF), 2015**: Channel mining revenues to local community's needs.

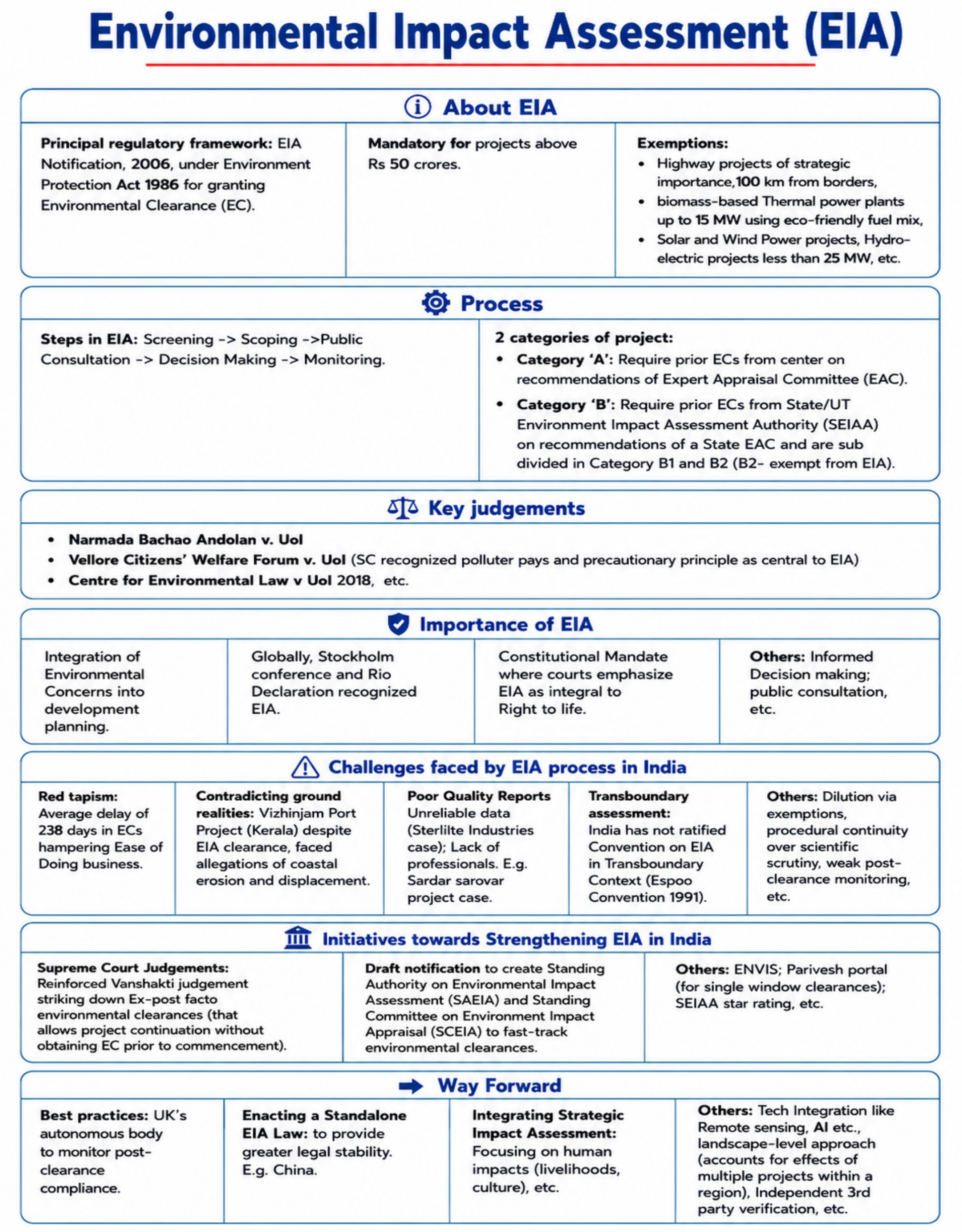
Way Forward

- **Regional & Climate-Specific Planning**: **Himalayas** (landslide-sensitive infrastructure), **Coastal Zones** (mangrove buffers, cyclone shelters), **Drylands** (micro-irrigation, drought-resistant crops).
- **Strengthen Environmental Justice System**: Fast-track NGT, improve capacity of State Pollution Control Boards, etc.
- **Participatory Decision-Making**: Social audits can include local communities in project planning.
- **Green Livelihood Programmes**: Scale up eco-tourism, bamboo-based livelihoods, etc.
- **Just Transition Fund**: Fund for workers affected by mine closures, green shifts or seasonal bans (especially fisheries).

Conclusion

In **Auroville Foundation** case, Supreme Court emphasized balancing industrial development and environmental protection where both goals should be pursued together without harming other.

3.2. ENVIRONMENT IMPACT ASSESSMENT (EIA) AT A GLANCE



Environmental Impact Assessment (EIA)

About EIA

Principal regulatory framework: EIA Notification, 2006, under Environment Protection Act 1986 for granting Environmental Clearance (EC).

Mandatory for projects above Rs 50 crores.

Exemptions:

- Highway projects of strategic importance,100 km from borders,
- biomass-based Thermal power plants up to 15 MW using eco-friendly fuel mix,
- Solar and Wind Power projects, Hydro-electric projects less than 25 MW, etc.

Process

Steps in EIA: Screening -> Scoping ->Public Consultation -> Decision Making -> Monitoring.

2 categories of project:

- **Category 'A':** Require prior ECs from center on recommendations of Expert Appraisal Committee (EAC).
- **Category 'B':** Require prior ECs from State/UT Environment Impact Assessment Authority (SEIAA) on recommendations of a State EAC and are sub divided in Category B1 and B2 (B2- exempt from EIA).

Key judgements

- **Narmada Bachao Andolan v. UoI**
- **Vellore Citizens' Welfare Forum v. UoI** (SC recognized polluter pays and precautionary principle as central to EIA)
- **Centre for Environmental Law v UoI 2018**, etc.

Importance of EIA

Integration of Environmental Concerns into development planning.

Globally, Stockholm conference and Rio Declaration recognized EIA.

Constitutional Mandate where courts emphasize EIA as integral to Right to life.

Others: Informed Decision making; public consultation, etc.

Challenges faced by EIA process in India

Red tapism: Average delay of 238 days in ECs hampering Ease of Doing business.

Contradicting ground realities: Vizhinjam Port Project (Kerala) despite EIA clearance, faced allegations of coastal erosion and displacement.

Poor Quality Reports Unreliable data (Sterlilte Industries case); Lack of professionals. E.g. Sardar sarovar project case.

Transboundary assessment: India has not ratified Convention on EIA in Transboundary Context (Espoo Convention 1991).

Others: Dilution via exemptions, procedural continuity over scientific scrutiny, weak post-clearance monitoring, etc.

Initiatives towards Strengthening EIA in India

Supreme Court Judgements: Reinforced Vanshakti judgement striking down Ex-post facto environmental clearances (that allows project continuation without obtaining EC prior to commencement).

Draft notification to create Standing Authority on Environmental Impact Assessment (SAEIA) and Standing Committee on Environment Impact Appraisal (SCEIA) to fast-track environmental clearances.

Others: ENVIS; Parivesh portal (for single window clearances); SEIAA star rating, etc.

Way Forward

Best practices: UK's autonomous body to monitor post-clearance compliance.

Enacting a Standalone EIA Law: to provide greater legal stability. E.g. China.

Integrating Strategic Impact Assessment: Focusing on human impacts (livelihoods, culture), etc.

Others: Tech Integration like Remote sensing, AI etc., landscape-level approach (accounts for effects of multiple projects within a region), Independent 3rd party verification, etc.

3.2.1. PUBLIC CONSULTATION AND ENVIRONMENT IMPACT ASSESSMENT (EIA)

Why in the News?

MoEFCC exempted **mining projects** involving **Atomic, Critical,** and **Strategic minerals (like Rare Earth Elements)** from **Public Consultation** under EIA.

What is Public Consultation in EIA?

- **Definition:** Process for ascertaining concerns of **local persons** and **other stakeholders.**
- It is required for usually all **Category A** and **Category B1** projects.
- **Two Components of Public Consultation:**
  - **Public hearing** on site or in close proximity.
  - **Written responses** from stakeholders.
- **Conducting Agency**: State Pollution Control Board (SPCB) or Union Territory Pollution Control Committee (UTPCC).
  - Proceedings to be sent to **concerned regulatory authority** within **45 days** of receiving applicant's request.

Why have these projects been exempted from Public Consultation?

- **Energy Security:** Thorium extracted from **Monazite** (Beach sand mineral) to be used in **3rd stage** and **Uranium** in **1st stage** of India's **Nuclear Power Programme**.
- **Strategic Applications:** E.g., in the defence sector, Rare Earth Elements (REEs) are used in production of surveillance and navigational aids (such as radar and sonar), etc.
- **Reducing Import Dependence and Supply chain disruption**: REEs production and supply is concentrated in limited geographies around the world.
- **Others:** Attract investments by reducing operationalization time, enabling speedy approvals, promoting economic competitiveness etc.

Concerns associated with Exemption of Public Consultation

- **Diluting Environmental Governance:** Undermines Legal Mandate under EIA 2006.
  - **Weakens Environmental Democracy** under **Article 21 (Right to Life, Clean Environment)** and **Article 48A (Protection of Environment).**
- **Reduces Quality of Project Appraisal**: Local population raises **site-specific concerns.** E.g., Silkyara tunnel under Char Dham project collapsed in 2023, was exempted from EIA.
- **Triggers Conflict due to Non-Engagement**: E.g., Closure of Sterlite Copper Plant in Tamil Nadu.
- **Undermines Participatory Governance:** It is based upon citizens **owning a voice in policy formulation** and **implementation** that impact or influence them.
- **Violation of International Commitments:** Rio Declaration (1992) and Aarhus Convention (1998).
  - **1998 Aarhus Convention** concerns access to justice in environmental matters.

Conclusion

A **balanced approach** i.e. ensuring speedy approvals without compromising transparency, accountability, and sustainability is essential.

3.2.2. ENVIRONMENT AUDIT RULES, 2025

Why in the News?

Ministry of Environment, Forest and Climate Change (**MoEFCC)** notified **Environment Audit Rules, 2025**.

What is an Environment Audit (EA)?

- Systematic audit, **verification**, **examination**, **inspection**, or **analysis** of any project, activity or process having a bearing on the environment.
  - EA differs from **EIA**, as the latter is conducted prior to the establishment of a project.

- Introduced in India in 1992 through **Rule 14 of Environment (Protection) Rules, 1986.**
  - Mandates entities engaged in industries, operations, or processes requiring consent under the **Water (Prevention and Control of Pollution) Act, 1974**, the **Air (Prevention and Control of Pollution) Act, 1981**, or under **Hazardous Wastes (Management and Handling) Rules, 1989**, to submit an annual environmental statement (Report).
    - Report is submitted to **State Pollution Control Board (SPCB) each year.**

About Environment Audit Rules, 2025

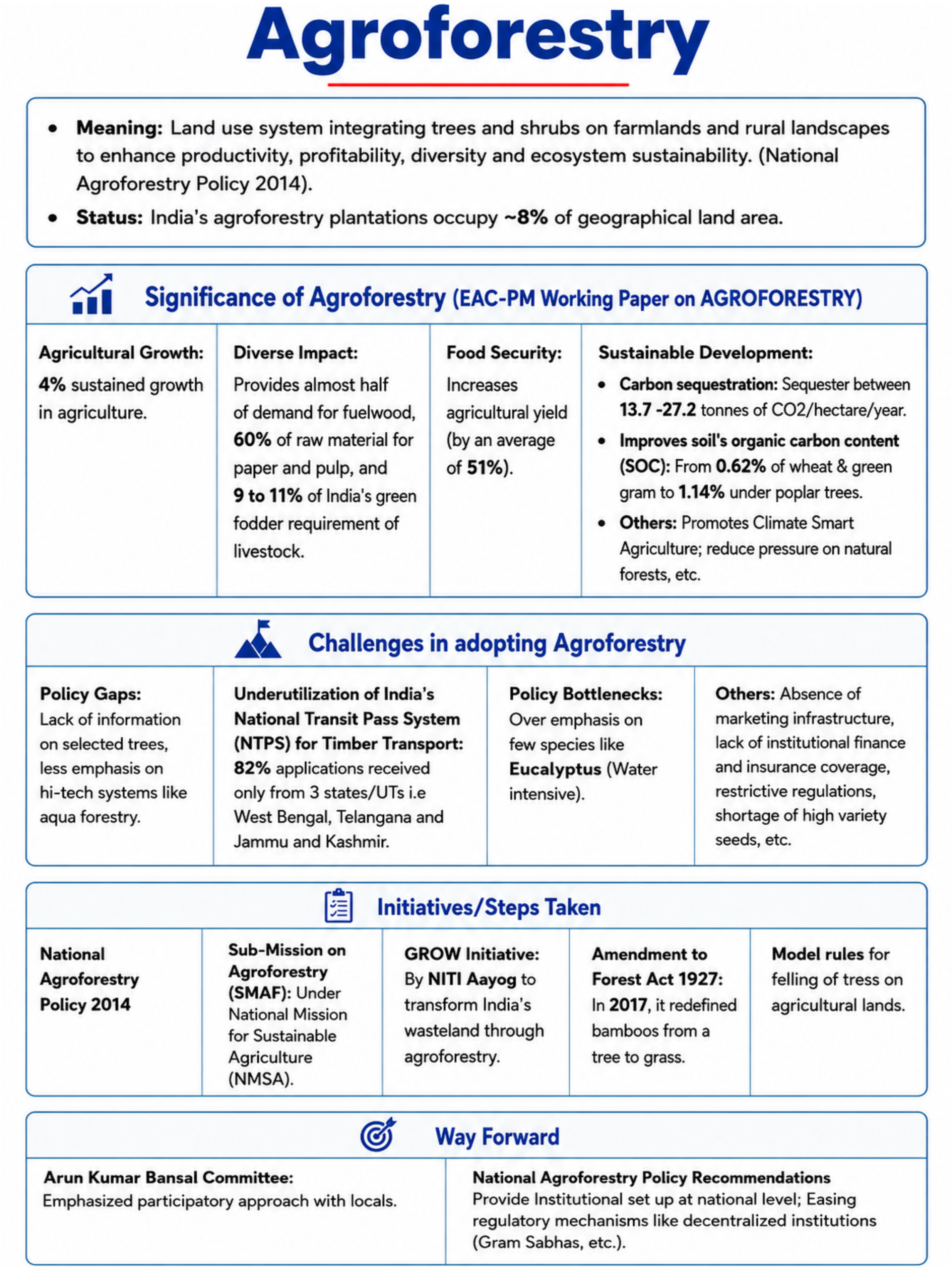
- **Objective:** Creating a **formal framework for environmental auditing** across the **country**
- **Significance:** Strengthens compliance through **third-party audits**, aligns with global frameworks **(Eco-mark, EPR, ESG, green bonds)**.
- Developed under **Environment Protection Act (1986).**
  - Comply with legal safeguards under various laws including **Van (Sanrakshan Evam Samvardhan) Adhiniyam (1980)**, the **Wildlife Protection Act (1972)**, etc.
- **Environment Audit Designate Agency (EADA):** EADA's responsibilities include certification, registration, oversight, and training of auditors.
- **Registered Environment Auditors (EAs):** Auditing to be undertaken only by REAs.
- **Certification and Registration**: Environment Auditors (EAs) will be **certified** and **registered by Environment Audit Designate Agency (Notified by MoEFCC).**
  - **Modes of Certification:**
    - **Recognition of Prior Learning (RPL)** or National Certification Examination (NCE).
  - **Responsibility**:
    - **Compliance evaluation** and **related activities of sampling, analysis, compensation calculation, verification** under **Green Credit Rules and other legislations.**
    - May undertake auditing assignments by Project Proponents (PPs) **including for verification of self-compliance reports.**
    - Environment audit under EIA, 2006, Coastal Regulation Zone (CRZ), 2011, etc.
  - The certification of Environmental Auditors will be based on **either scrutiny of their qualification** and experience or by **conducting an exam.**
  - REAs are assigned **using a random assignment method** to **ensure impartiality.**
- **Two-Tiered System:**
  - **Tier-1:** Comprises existing government regulator-based review of compliance by agencies like CPCB, SPCBs, and ministry regional offices.
  - **Tier-2:** Involves an environment auditor-based mechanism.
- **Ministry of Environment, Forest and Climate Change:** Oversees implementation.
- **CPCB/SPCB/ROs:** Continue inspection and verification roles, assist MoEFCC in implementation.
- **Oversight Mechanism:** Steering Committee, led by an Additional Secretary from MoEFCC.

Conclusion

Outcome of environmental audits will offer vital inputs for effective conservation and rejuvenation efforts and support India’s climate commitments through adoption of LiFE (Lifestyle for Environment).

3.3. SUSTAINABLE AGRICULTURE IN INDIA

3.3.1. AGROFORESTRY AT A GLANCE



Agroforestry

- **Meaning:** Land use system integrating trees and shrubs on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability. (National Agroforestry Policy 2014).
- **Status:** India's agroforestry plantations occupy **~8%** of geographical land area.

Significance of Agroforestry (EAC-PM Working Paper on AGROFORESTRY)

Agricultural Growth:	Diverse Impact:	Food Security:	Sustainable Development:
4% sustained growth in agriculture.	Provides almost half of demand for fuelwood, **60%** of raw material for paper and pulp, and **9 to 11%** of India's green fodder requirement of livestock.	Increases agricultural yield (by an average of **51%**).	**Carbon sequestration:** Sequester between **13.7 -27.2** tonnes of CO2/hectare/year. **Improves soil's organic carbon content (SOC):** From **0.62%** of wheat & green gram to **1.14%** under poplar trees. **Others:** Promotes Climate Smart Agriculture; reduce pressure on natural forests, etc.

Challenges in adopting Agroforestry

Policy Gaps:	**Underutilization of India's National Transit Pass System (NTPS) for Timber Transport:**	**Policy Bottlenecks:**	**Others:**
Lack of information on selected trees, less emphasis on hi-tech systems like aqua forestry.	**82%** applications received only from 3 states/UTs i.e West Bengal, Telangana and Jammu and Kashmir.	Over emphasis on few species like **Eucalyptus** (Water intensive).	Absence of marketing infrastructure, lack of institutional finance and insurance coverage, restrictive regulations, shortage of high variety seeds, etc.

Initiatives/Steps Taken

National Agroforestry Policy 2014	**Sub-Mission on Agroforestry (SMAF):**	**GROW Initiative:**	**Amendment to Forest Act 1927:**	**Model rules**
	Under National Mission for Sustainable Agriculture (NMSA).	By **NITI Aayog** to transform India's wasteland through agroforestry.	In **2017**, it redefined bamboos from a tree to grass.	for felling of tress on agricultural lands.

Way Forward

Arun Kumar Bansal Committee:	**National Agroforestry Policy Recommendations**
Emphasized participatory approach with locals.	Provide Institutional set up at national level; Easing regulatory mechanisms like decentralized institutions (Gram Sabhas, etc.).

3.3.2. CLIMATE RESILIENT AGRICULTURE AT A GLANCE

Climate Resilient Agriculture

About Climate Resilient Agriculture (CRA)

Refers to adopting **adaptation and mitigation practices** in agriculture to enhance system's ability to **withstand climate shocks and recover quickly.**

Significance of CRA

Preventing Yield loss: Climate change can reduce yields by **4.5 to 9.0%** resulting around **1.5% GDP loss per year (Parliamentary Standing Committee on Agriculture)**

Protecting Livelihoods: Around **57%** of rural households depend on farming for income. **(All-India Rural Financial Inclusion Survey (NAFIS)-2021-22)**

Rainfed Area Vulnerability: **51%** of India's net sown area is rainfed.

Food security: Climate change impact on agri and allied sector can cause undernourishment, child malnutrition, micronutrient deficiency etc.

Challenges in Adopting CRA

Multidimensional Intervention
- Requires action across multiple scales and sectors.
- Demands coordination among diverse stakeholders.

Skill Issues
- Weak extension services and research-farmer linkages.
- Lack of training, knowledge and widespread illiteracy

Structural Issues
- Dependence on rainfall.
- Inadequate seed supply and post-harvest infrastructure.
- Fragmented landholding

Policy Issues

MSP and fertilizer subsidies encourage monoculture, groundwater depletion and soil degradation.

Initiatives/Steps Taken

National Innovations in Climate Resilient Agriculture (NICRA): Recently launched Atlas of Climate Adaptation in Indian Agriculture (**ACASA-India**) to help farmers plan for climate challenges.

Paramparagat Krishi Vikas Yojana (PKVY) and Soil Health Card Scheme

National Mission for Sustainable Agriculture (NMSA)

Food & Agriculture for Sustainable Transformation (FAST) Partnership

Way Forward

Institutional Measures: Create a Single Nodal Agency at the national level for climate and agriculture-related issues.

Technology Adoption: Use AI-driven analytics and decision support systems

Promote Heat-Tolerant Varieties: such as: **Wheat:** HDCSW-18, DBW-187, **Rice:** CR Dhan 201, NICRA Aerobic Dhan 1, CR Dhan 412

Upscaling Proven Practices: Nationwide adoption of Climate Resilient Villages (CRVs) under NICRA.

3.4. MISCELLANEOUS

3.4.1. CIRCULAR ECONOMY

Why in the news?

World is rapidly Progressing towards **"Circular Economy"** with government earning more than **Rs 4,000 crore from Scrap** including E-Waste during Swachhata campaign.

About Circular Economy

- **Meaning:** Economic system that uses a **systemic approach** to maintain a **circular flow of resources** by **recovering, retaining, or adding to their value**, while contributing to sustainable development (International Organization for Standardization).
    - It is in contrast to traditional, linear economic model based on **take-make-consume-throw away pattern.**
- **Potential In India:** Market value of over **$2 trillion and 10 million jobs** by **2050.**
- **Key Benefits of Circular Economy:** Reduction in waste generation; Preservation of Natural Capital; Reducing raw material dependence; etc.

Key Challenges in achieving Circularity in India

- **Informal and inefficient collection: ~78%** of India's total E-waste is processed by informal sector, achieving **material recovery rates of only 10-20%** compared to 95-97% in formal facilities.
- **Weak monitoring & enforcement:** Manipulation of Extended Producer Responsibility (EPR) system. E.g. spurious EPR certificates.
- **Limited EPR coverage:** Only a few metals dominate, Iron (52%), Copper (18%) etc.; **critical minerals (such as Lithium and Cobalt) remain neglected.**
- **Downcycling:** Process of recycling materials into products of lower value and quality.

Key Measures taken towards Circular Economy in India

- **Policy/Rules:** Framework of **Extended Producer Responsibility (EPR)**; **Battery Waste Management Rules (BWMR), 2022; E-waste Management Rules (EWMR), 2022, etc.**
- **Enabling Schemes: Swachh Bharat Mission** (make India Zero Waste country); **Atal Innovation Mission** (supporting development of **circular business models**), etc.
- **Research and Development: Circular Economy Cell** at NITI Aayog.
- **Sector Level Policies: Steel Scrap Recycling Policy; MSE-Scheme for promotion and investment in circular economy (MSE-SPICE); etc.**
- **Global Leadership Efforts: Jaipur Declaration** at 12th (2025) Regional 3R (Reduce, Reuse, and Recycle) and Circular Economy Forum in Asia and Pacific, **Mission LiFE, etc.**

Way Forward

- **Monitoring recyclers** through **expanded EPR coverage to include high-value metals.**
- Integrate **Battery recycling into Indian Carbon Market**, allowing recyclers to monetize Green House Gas (GHG) emission reductions.
- **Informal Sector Integration** by using **single-window system**; **establishing a separate vertical** in National Critical Mineral Mission (NCMM) only on recycling.
- **Global Best Practices,** e.g., **South Korea's** strict penalties for non-compliance can reach **up to 130% of recycling cost**.

Conclusion

By **scaling proven interventions, strengthening local institutions, and aligning economic incentives with ecological outcomes**, circular economy can play a pivotal role in ensuring long-term food security, climate resilience, and inclusive development.

3.4.2. GREAT NICOBAR ISLAND PROJECT (GNIP)

Why in the News?

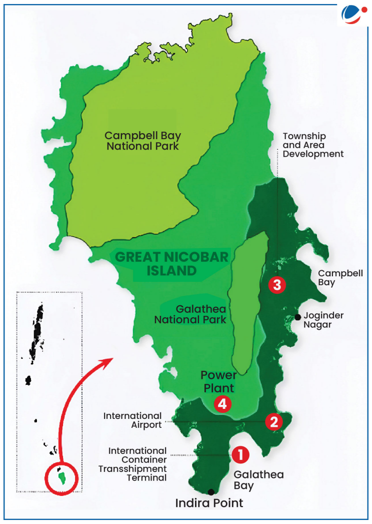
Union Ministry of Tribal Affairs sought report form Andaman and Nicobar Islands administration on complaint that **forest rights had not been settled** under Forest Rights Act, 2006 for GNIP.

More on the News

- Tribal Councils in Andaman and Nicobar Islands (ANI) are **statutory bodies under Andaman and Nicobar Islands (Tribal Councils) Regulation, 2009.**
    - They have **limited advisory and executive powers**, unlike autonomous councils under the Sixth Schedule of the Constitution.
- ANI administration maintained that it **does not need to implement Forest Rights Act (FRA),** as tribal rights were already protected under **Protection of Aboriginal Tribes Act, 1956 (PAT,56).**
    - **PAT,56** gives local **administration unilateral authority to divert forest land**, whereas **FRA** mandates **consent to be obtained from the Gram Sabhas** concerned.

About Great Nicobar Island Project

- **Genesis:** Greenfield infrastructure project conceived by NITI Aayog, approved by Union Cabinet in 2021.
- **Nodal Agency:** Andaman and Nicobar Islands Integrated Development Corporation (ANIIDCO), incorporated in 1988 as a **Government Undertaking under the Companies Act 1956**.
- **Project Components:**
    - **International Transshipment Port: Galathea Bay,** Deep-sea port on island's southern coast.
        - Overseen by **Ministry of Ports, Shipping and Waterways**.
    - **A Greenfield international airport**
    - **A 450 MW** power plant
    - A modern **township**
- **Significance of Project:** Utilise geostrategic location of ANI (Near Malacca, Sunda, Lombok Strait); attract cargo traffic; improve connectivity; bolster defence, support economic growth and regional development.



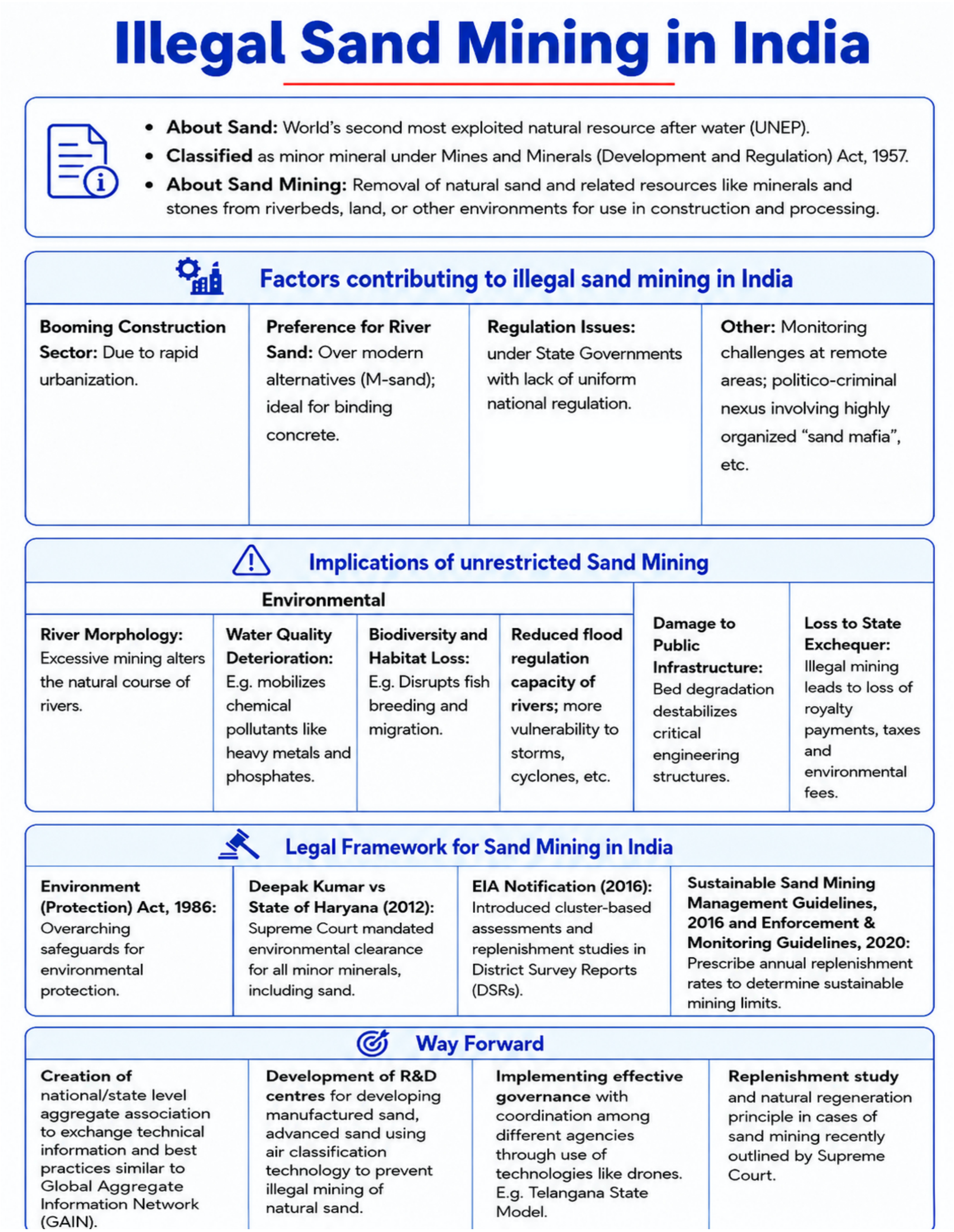
Ecological, Social and Geological Concerns

- **Tribal Rights:** Negatively impact **Shompens** (Particularly Vulnerable Tribal Group) and **Nicobarese** causing displacement, exposing Shompens to infectious diseases, etc.
- **Ecological Concerns:**
    - **Impact on Species: Galathea Bay**, (**protected wetland** under Ramsar Convention), most important **nesting site for endangered Leatherback Sea Turtle**.
    - **Deforestation:** Cutting ~9.6 lakh trees **negatively impacting carbon sequestration.**
    - **Shoreline Changes:** Undermine **natural coastal defences**. (mangrove belts at Galathea).
- **Geological and Disaster Risks:** Great Nicobar sits atop the **megathrust fault line** that triggered the 2004 Indian Ocean tsunami.

Conclusion

A path forward in such developmental project lies in adopting a **phased, ecologically sensitive, and community-inclusive model of development** that safeguards biodiversity and cultural heritage.

3.4.3. ILLEGAL SAND MINING IN INDIA AT A GLANCE



Illegal Sand Mining in India

- **About Sand:** World's second most exploited natural resource after water (UNEP).
- **Classified** as minor mineral under Mines and Minerals (Development and Regulation) Act, 1957.
- **About Sand Mining:** Removal of natural sand and related resources like minerals and stones from riverbeds, land, or other environments for use in construction and processing.

Factors contributing to illegal sand mining in India

Booming Construction Sector: Due to rapid urbanization.	**Preference for River Sand:** Over modern alternatives (M-sand); ideal for binding concrete.	**Regulation Issues:** under State Governments with lack of uniform national regulation.	**Other:** Monitoring challenges at remote areas; politico-criminal nexus involving highly organized "sand mafia", etc.

Implications of unrestricted Sand Mining

Environmental					
River Morphology: Excessive mining alters the natural course of rivers.	**Water Quality Deterioration:** E.g. mobilizes chemical pollutants like heavy metals and phosphates.	**Biodiversity and Habitat Loss:** E.g. Disrupts fish breeding and migration.	**Reduced flood regulation capacity of rivers;** more vulnerability to storms, cyclones, etc.	**Damage to Public Infrastructure:** Bed degradation destabilizes critical engineering structures.	**Loss to State Exchequer:** Illegal mining leads to loss of royalty payments, taxes and environmental fees.

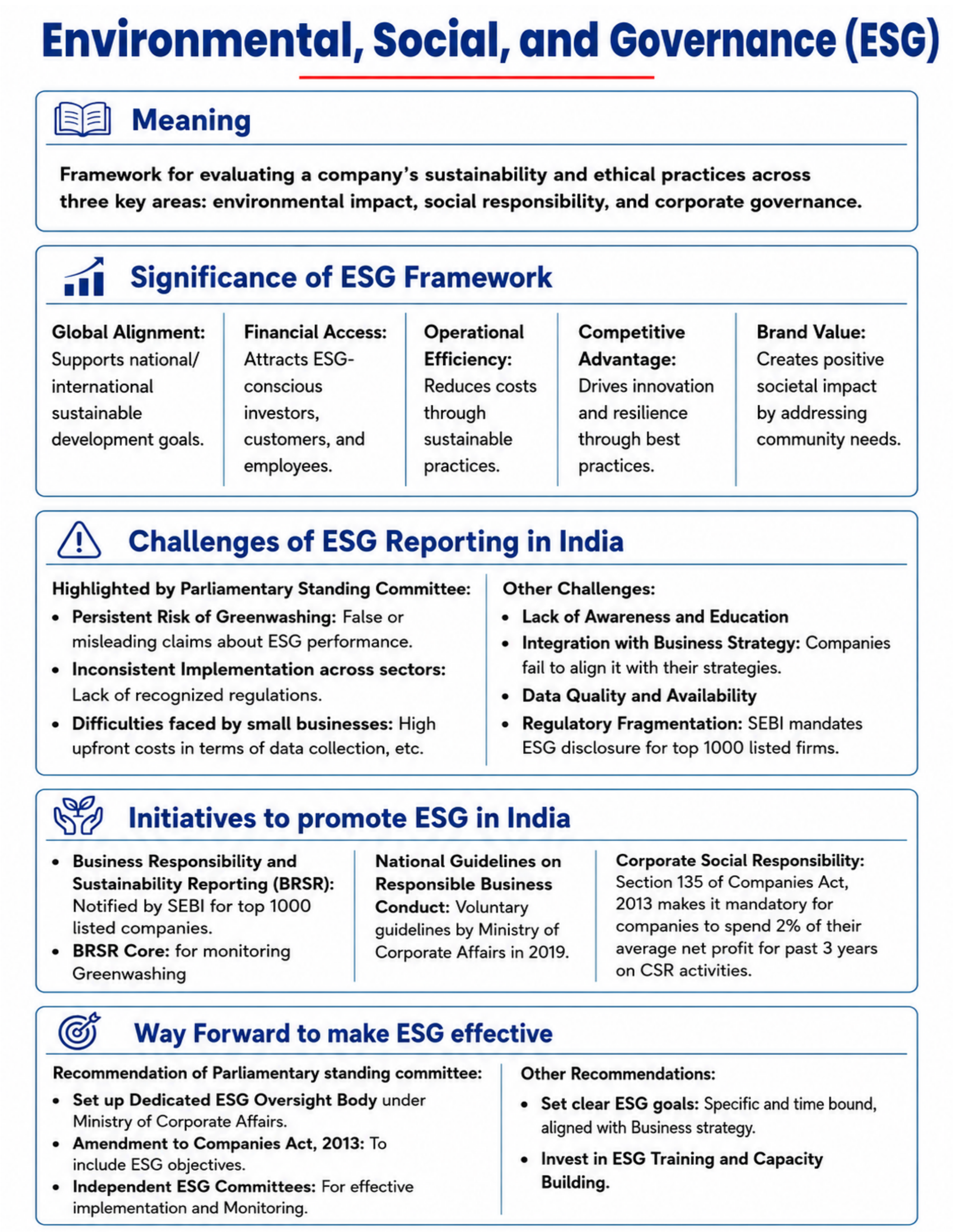
Legal Framework for Sand Mining in India

Environment (Protection) Act, 1986: Overarching safeguards for environmental protection.	**Deepak Kumar vs State of Haryana (2012):** Supreme Court mandated environmental clearance for all minor minerals, including sand.	**EIA Notification (2016):** Introduced cluster-based assessments and replenishment studies in District Survey Reports (DSRs).	**Sustainable Sand Mining Management Guidelines, 2016 and Enforcement & Monitoring Guidelines, 2020:** Prescribe annual replenishment rates to determine sustainable mining limits.

Way Forward

Creation of national/state level aggregate association to exchange technical information and best practices similar to Global Aggregate Information Network (GAIN).	**Development of R&D centres** for developing manufactured sand, advanced sand using air classification technology to prevent illegal mining of natural sand.	**Implementing effective governance** with coordination among different agencies through use of technologies like drones. E.g. Telangana State Model.	**Replenishment study** and natural regeneration principle in cases of sand mining recently outlined by Supreme Court.

3.4.4. ENVIRONMENTAL, SOCIAL, AND GOVERNANCE (ESG) AT A GLANCE



Environmental, Social, and Governance (ESG)

Meaning

Framework for evaluating a company's sustainability and ethical practices across three key areas: environmental impact, social responsibility, and corporate governance.

Significance of ESG Framework

Global Alignment: Supports national/ international sustainable development goals.

Financial Access: Attracts ESG-conscious investors, customers, and employees.

Operational Efficiency: Reduces costs through sustainable practices.

Competitive Advantage: Drives innovation and resilience through best practices.

Brand Value: Creates positive societal impact by addressing community needs.

Challenges of ESG Reporting in India

Highlighted by Parliamentary Standing Committee:

- **Persistent Risk of Greenwashing:** False or misleading claims about ESG performance.
- **Inconsistent Implementation across sectors:** Lack of recognized regulations.
- **Difficulties faced by small businesses:** High upfront costs in terms of data collection, etc.

Other Challenges:

- **Lack of Awareness and Education**
- **Integration with Business Strategy:** Companies fail to align it with their strategies.
- **Data Quality and Availability**
- **Regulatory Fragmentation:** SEBI mandates ESG disclosure for top 1000 listed firms.

Initiatives to promote ESG in India

- **Business Responsibility and Sustainability Reporting (BRSR):** Notified by SEBI for top 1000 listed companies.
- **BRSR Core:** for monitoring Greenwashing

National Guidelines on Responsible Business Conduct: Voluntary guidelines by Ministry of Corporate Affairs in 2019.

Corporate Social Responsibility: Section 135 of Companies Act, 2013 makes it mandatory for companies to spend 2% of their average net profit for past 3 years on CSR activities.

Way Forward to make ESG effective

Recommendation of Parliamentary standing committee:

- **Set up Dedicated ESG Oversight Body** under Ministry of Corporate Affairs.
- **Amendment to Companies Act, 2013:** To include ESG objectives.
- **Independent ESG Committees:** For effective implementation and Monitoring.

Other Recommendations:

- **Set clear ESG goals:** Specific and time bound, aligned with Business strategy.
- **Invest in ESG Training and Capacity Building.**

3.4.5. LAND SUBSIDENCE

Why in the news?

Study found land subsidence in **Delhi (National Capital Territory, NCT), Mumbai, Kolkata, Bengaluru** and **Chennai** due to excessive groundwater extraction.

Key Highlights of the Study

- **Impact:** Impacted nearly **80 million people** with **Delhi** recording highest sinking rate of 51 mm annually.
- **Localised Uplift:** Study identified **localised uplift in some cities**, like areas near Dwarka in Delhi.

About Land Subsidence

- **Meaning:** Gradual or sudden **sinking of earth's surface** caused by **compression or weakening of soil** and rock layers beneath.
- **Primary Causative Factors:** Excessive **groundwater pumping, large-scale mining**, **rapid urbanisation, natural shifts** in earth's crust, etc.
- **Areas Witnessing Subsidence:** Areas around **Assam and Sikkim** (fault activity and hydrocarbon extraction), **Himalayan towns** like Joshimath and Mussoorie (unregulated development), etc.

Impacts of Land Subsidence

- **Impact on Infrastructure:** Study estimates more than **2000 buildings in Delhi** are currently at high damage risk due to **differential land subsidence.**
- **Impact on Coastal Regions:** They witness **saltwater intrusion**, leading to freshwater contamination and crop loss.
- **Disasters:** Buildings crack or collapse, roads buckle, and drainage networks misalign, often leading to floods.
- **Long-term ecological risk:** It **alters river flows, affects aquatic and terrestrial habitats**, and may accelerate **carbon release from peatlands and marshes.**

Conclusion

Solutions like **artificial recharge of depleted aquifers** along with advanced monitoring techniques like **PSInSAR (cities), SBAS-InSAR (agricultural areas), and SqueeSAR (mountaineous terrains)** should be deployed.

3.4.6. ENVIRONMENTAL IMPACT OF CONFLICTS

Why in the news?

Ongoing global conflicts like USA-Iran pose serious **environmental risks**, including potential for radioactive contamination from Iran's nuclear sites.

Impact of Conflicts/War on Environment

- **Greenhouse Gas Emissions:** Global militaries contribute ~**5.5% of global emissions.**
- **Pollution and Contamination:** E.g., in Ukraine, landmines and unexploded ordnance pose long-term risks, with soil, water, and forests polluted by conflict whose **cleanup may cost around US$34.6 billion**.
- **Resource Depletion and Biodiversity Loss:** E.g., during Vietnam War, use of herbicides like **Agent Orange** resulted in defoliation of vast forested areas.

International Agreements

- **Paris Agreement 2015:** It made reporting of **military emissions** voluntary.
- **Rome Statute of International Criminal Court 1998:** Describes widespread, long-term, and damage to environment during international armed conflict as **war crime.**

- **Convention on Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD)**

Conclusion

Recognizing the **grave impact of conflict on environment** is the first step towards **mitigating harm, promoting environmental remediation,** and ultimately, **preventing future conflicts.**

3.4.7. ENVIRONMENTAL LAWS

Why in the news?

Systematic "watering down" of environmental protections characterized by the judicial recall of progressive judgments, adoption of reductionist definitions for protected areas (Aravalli hills), etc. have been observed lately.

Systematic Dilution of Environmental Regulation

- **EIA Process Undermined:** Since December 18, 2025, for non-coal mining projects, land acquisition can occur before an Environmental Impact Assessment (EIA).
- **Judicial recalls**: **Vanashakti vs Union of India (2025) diluted the ban on retrospective clearances,** signaling a **retreat from pro-environment jurisprudence.**
- **Aravalli Hills Controversy: Supreme Court (SC)** accepted a **100-metre height-based definition, excluding large ecologically vital areas from protection** impacting violation of **Article 21, weakens article 48A.**
- **Mangroves & Coastal Ecology:** Judicial approval for destruction of **mangroves (e.g., Raigarh, Maharashtra for Adani Cementation Ltd.)** reflects reliance on **compensatory afforestation and ignores ecological science.**
- **Strategic Defense vs. Ecology:** Court allowed wider roads based on strategic defense needs despite recognizing the area's ecological importance. **(Citizens for Green Doon vs Union of India, 2021).**
- **Federal Environmental Governance: E.g.** Wildlife Protection (Kerala Amendment) Bill, 2025 marks tension in Federal Environmental Governance.

Constitutional and Jurisprudential Implications

- **Constitutional provisions at risk: Article 14** (equality before law), **Article 21** (right to clean and healthy environment), **Article 51A(g)** (fundamental duty of citizens to safeguard the environment).
- **Erosion of Public Trust doctrine:** Established in **M.C. Mehta vs. Kamal Nath (1996),** it asserts that natural resources belong to state in trust for people and cannot be sold for private exploitation.

Ways for Effective Resolution of Issues

- **Proper Monitoring and Government Accountability** to check diversion of **green tax funds** (levied on the districts accorded with special status) for unrelated purposes.
- **Addressing Illicit Operations** like Mining and quarrying by **offering alternative income sources**.
- Opinion of **Geologists, Environmental Experts and local people** to be taken before starting developmental projects.
- **Sustainable Solid Waste Management** through Localised segregation, community awareness, and decentralised processing.
- **Apply Polluter Pays Principle**, penalties **must be proportionate to the financial capacity of violators**, as uniform fines fail to deter large corporations.

Landmark Environmental Cases in India that strengthened Environmental Laws

- **M.C. Mehta v. Union of India (1986) case (**recently officially closed): SC recognized the principle of Absolute Liability and applied Doctrine of Public Trust to natural resources.
    - It also led to lead free petrol in India, coastal management plans in states, shifting of stone crushers out of Delhi etc.

- **T.N. Godavarman Thirumulpad Case (1995):** Expanded the definition of forest land to include all areas recorded as forests in government records, regardless of ownership.
- **Vellore Citizens Welfare Forum Case (1996):** Recognized the Precautionary Principle and the Polluter Pays Principle as essential features of Indian environmental law.
- **S.P. Muthuraman Case (2025)**: SC declared post-facto or retrospective environmental clearances illegal.

Conclusion

Environmental rule of law is an integral component of India's **progressive environmental jurisprudence**, recognising the **link between human rights and healthy environment** and must be strengthened.

3.5. KEYWORDS

Financing for SDGs	Sevilla Commitment	Agroforestry	Environmental Audit	Public Consultation
Soil Health	Sustainable Agriculture	SDG Localization	Illegal Sand Mining	Land Subsidence
Environmental, Social and Governance	Circular Economy	Environmental Rule of Law	Climate Resilient Agriculture	Environmental Impact Assessment (EIA)

3.6. PRACTICE QUESTION

'The Space between national priorities and delivery on the ground is where local action adds powerful value and impact'. In the light of the above statement, explain the significance of localized action for realizing Sustainable Development Goals (SDGs). Also discuss the key challenges in this regard.

Introduction	Body Part 1	Body Part 2	Conclusion
Explain in one-line what localisation of SDGs mean.	Mention the key significance of localisation.	Highlight the key challenges in localizing SDGs.	Highlight India's efforts. E.g., work of NITI Aayog.

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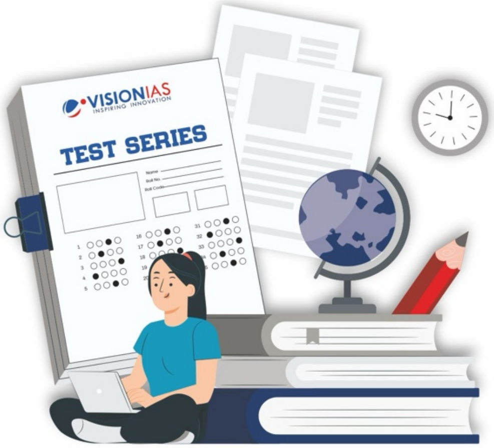

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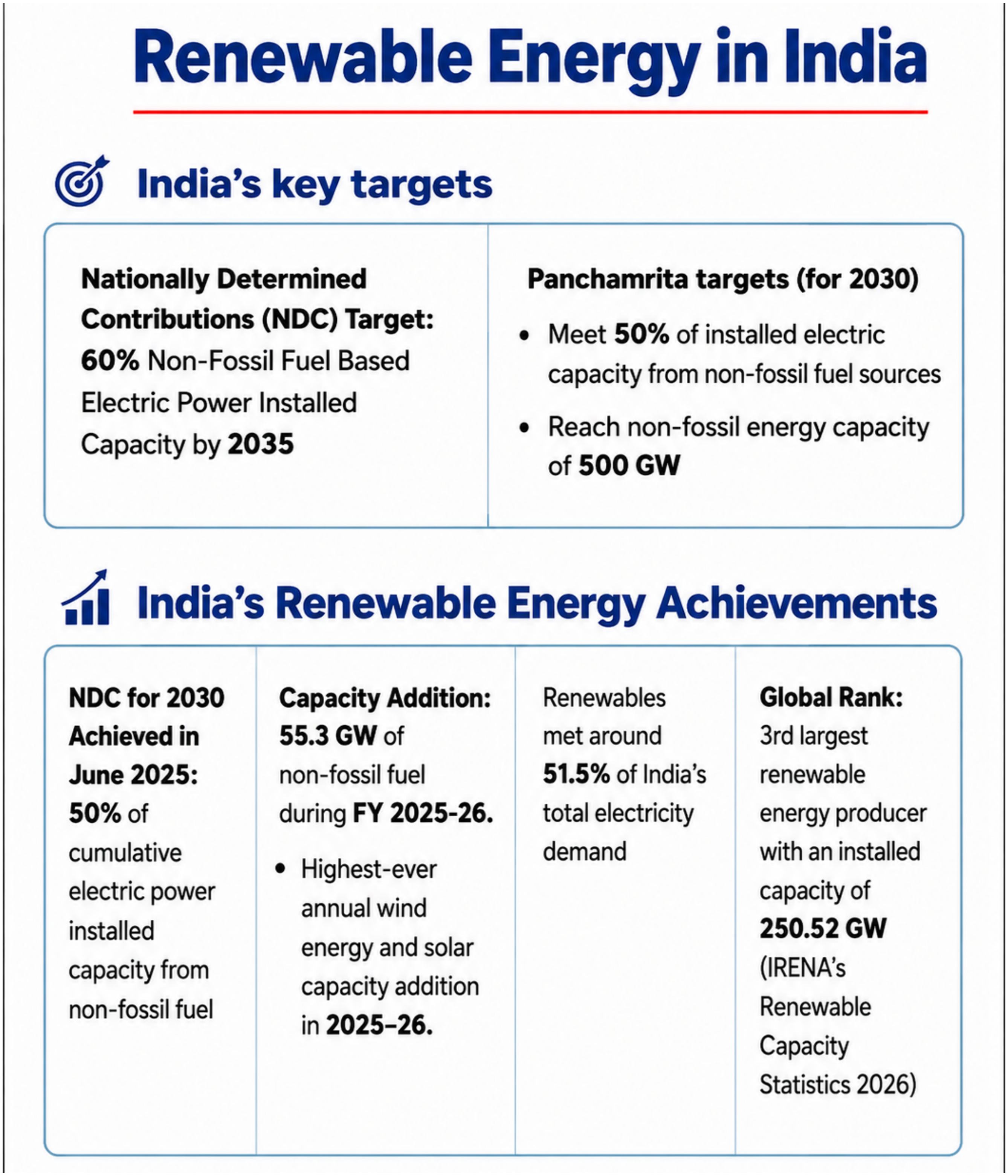
4. RENEWABLE ENERGY AND ALTERNATIVE ENERGY RESOURCES

4.1. RENEWABLE ENERGY IN INDIA AT A GLANCE



Renewable Energy in India

India's key targets

Nationally Determined Contributions (NDC) Target: **60%** Non-Fossil Fuel Based Electric Power Installed Capacity by **2035**

Panchamrita targets (for 2030)

- Meet **50%** of installed electric capacity from non-fossil fuel sources
- Reach non-fossil energy capacity of **500 GW**

India's Renewable Energy Achievements

NDC for 2030 Achieved in June 2025: **50%** of cumulative electric power installed capacity from non-fossil fuel

Capacity Addition: **55.3 GW** of non-fossil fuel during **FY 2025-26.**

- Highest-ever annual wind energy and solar capacity addition in **2025–26.**

Renewables met around **51.5%** of India's total electricity demand

Global Rank: 3rd largest renewable energy producer with an installed capacity of **250.52 GW** (IRENA's Renewable Capacity Statistics 2026)

4.2. ENERGY TRANSITION

Why in the news?

India received strong global endorsement for India's Renewable Energy Transition Roadmap at WEF 2026.

Significance of Energy Transition for India

- **Energy Security:** Geopolitical conflicts, and global energy price volatility. **E.g. West Asia Crisis.**
- **Inclusive Development:** Decentralized RE helps **Community Empowerment E.g.,** Barefoot Women Solar Engineers Programme.
- **RE Employment in India:** 1.3 million jobs (7.7% global share); 2nd in Solar photovoltaic and Hydropower employment (after China). (IRENA's Renewable Energy and Jobs – Annual Review 2025)
- **Climate Change Mitigation:** GHG emissions must peak before 2025 at the latest and decline 43% by 2030.

What makes India lead in Energy Transition?

- **High potential: 300+ sunny days annually;** wind energy potential **due to long coastline and elevated terrains etc.**
- **National policies:** E.g., Offshore Wind Energy Policy, 2015; National Wind–Solar Hybrid Policy, 2018; National Policy on Biofuels, 2018 etc.
- **Infrastructure Development: Green Energy Corridor (GEC); PM Surya Ghar Muft Bijli Yojana, PM KUSUM, etc.**
- **Regulatory & Market Reforms:** Renewable Purchase Obligations (RPO); Indian Carbon Market (2024) under Carbon Credit Trading Scheme (CCTS); 100% FDI in renewable energy under automatic route.
- **Dedicated schemes: National Green Hydrogen Mission (NGHM) Ethanol Blended Petrol (EBP) Programme; National Solar Mission (NSM); Small Hydro Power (SHP) Development Scheme etc.**
- **Expansion of Manufacturing** through PLI scheme, investment in transmission infrastructure, etc.
- **International collaborations**: International Solar Alliance (ISA), One Sun, One World, One Grid (OSOWOG), etc.

Challenges in Energy Transition

- **High Costs:** E.g., **Financing Gap:** USD 6.5 trillion by 2070 for Net zero.
- **High energy demand**: India's share in global primary energy consumption is projected to double by 2035.
- **Infrastructure Challenges:** High storage cost (~₹5–6 per unit storage cost); Land acquisition (solar needs 300 times more space than nuclear); complex grid upgrades etc.
- **High import dependence:** E.g., In FY 2025, India imported around 35 million solar modules worth USD 1.6 billion, majorly from China.
- **Economic losses:** Due to stranded fossil fuel assets (i.e., no longer economically viable).

Way Forward

- **Explore sustainable financing through mechanisms** like Just Energy Transition Partnership (JETP), green bonds, etc.
- **Promote Storage Technologies** like ACC batteries, pumped-storage hydropower, hybrid systems.
- **Scale Domestic Manufacturing** of Solar modules, green hydrogen technologies, etc.
- **Modernize transmission corridors**, **enable smart-grid systems** through AI/ML technologies.
- **Establish an Independent National Transition body** to oversee coal phase-out and Repurposing.

Conclusion

India's energy landscape has undergone a significant transformation based on the approach that emphasises **scale, implementation, and inclusion** while responding to **rising energy demand.**

4.3. ELECTRIC MOBILITY

Why in the news?

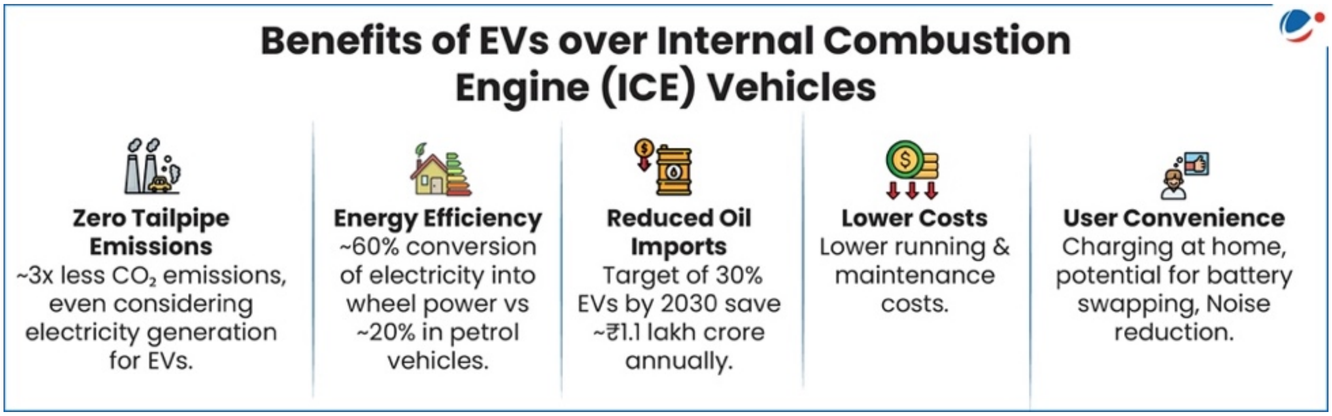
NITI Aayog released report "**Unlocking a 200 Billion Dollar Opportunity**: **Electric Vehicles (EVs) in India**" along with first **India Electric Mobility Index.**

About India Electric Mobility Index (IEMI)

- **First-of-its-kind** tool to benchmark states' progress in e-mobility, launched in partnership with World Resources Institute India.
- Tracks 16 performance indicators under 3 categories-**Transport Electrification Progress; Charging Infrastructure Readiness; EV Research & Innovation.**
- **Groups states into four categories:** Achievers (100), Front Runners (65–99), Performers (50–64), and Aspirants (0–49).
    - For 2024, **Delhi** topped (score 77), followed by **Maharashtra** (68).

About Electric Vehicles (EVs)

- **Types:**
    - **Battery EVs** (entirely battery-powered);
    - **Hybrid EVs** (both engine and electric motor);
    - **Fuel Cell EVs** (utilize 'fuel cell technology' to generate electricity for propulsion);
    - **Plug-in Hybrid EV** (uses both an engine and a rechargeable battery) etc.
- **Status in India (NITI Aayog): 7.6%** EV penetration in 2024, below **30% target for 2030**.



Benefits of EVs over Internal Combustion Engine (ICE) Vehicles

Zero Tailpipe Emissions ~3x less CO_2 emissions, even considering electricity generation for EVs.

Energy Efficiency ~60% conversion of electricity into wheel power vs ~20% in petrol vehicles.

Reduced Oil Imports Target of 30% EVs by 2030 save ~₹1.1 lakh crore annually.

Lower Costs Lower running & maintenance costs.

User Convenience Charging at home, potential for battery swapping, Noise reduction.

Challenges highlighted by report:

- **Financing vehicles,** especially electric buses and electric trucks which cost 2-3 times of ICE vehicles.
- **Charging infrastructure issues** like Problems in getting upstream power supply connections from DISCOMs, Land constraints in cities/highways, public charging almost 4 times expensive as home charging, etc.
- **Lack of adequate awareness** regarding EV performance among public and private stakeholders.
- **Inadequate data in VAHAN database and regulatory gaps** which hinders evidence-based decision making.
- **Inverted GST for manufacturers** as Input GST at 18% and output GST at 5%, which blocks the working capital and input tax gets piled up.

Steps taken by India to boost EV adoption

- **PM-Electric Drive Vehicle Incentive and Ecosystem (PM-E-DRIVE) scheme, 2024**: Supports e-2Ws, e-3Ws, e-trucks, e-buses, and charging infrastructure, etc.
- **Scheme to Promote Manufacturing of Electric Passenger Cars in India**.

- **PM e-Bus Sewa – PSM (Payment Security Mechanism): Targets** deployment of 38,000+ e-buses.
- **National Electric Mobility Mission Plan (NEMMP) 2020**, envisioned to achieve 6-7 million sales of hybrid and electric vehicles year on year from 2020 onwards.
- **GST on EVs cut** from 12% to 5%.
- **Others: PLI Scheme for Automobile & Auto Components; PLI – Advanced Chemistry Cell**; **e VITARA", Suzuki's first Made-in-India** global strategic Battery Electric Vehicle **(BEV);** local production of **hybrid battery electrodes in Gujarat, etc.**

Way Forward: Recommendations highlighted in report

- **Incentives to Mandates:** Set target for production of Zero Emission Vehicles (ZEVs); etc.
- **Saturation Approach**: E.g. 100% electric mobility adoption across **5 Indian cities within 5 years.**
- **Financing e-Buses and e-Trucks**: **Pooled fund** from public and multilateral sources for low-interest loans.
- **Strategic Charging Infrastructure:** Develop 20 key corridors, set up nodal agencies, map hub locations, etc.
- **Adopting Global Best Practices**: "**10 Cities, 1000 Vehicles**" program (China); **ChargeMap app** (Europe); Singapore's **EVElectric Charging Pte Ltd (EVe)** company, etc.
- **Others**: Awareness and Information; research through academia-industry-government partnerships; lowering upfront cost to aid small operators and battery as a service (BaaS), etc.

Conclusion

To propel scale adoption of EVs, it is essential to building a **unified National App** that provides services relating to charging along with **developing strategic charging infrastructure** to reap full benefits of green mobility.

4.4. NATIONAL BIOENERGY PROGRAMME

Why in the News?

The Ministry of New and Renewable Energy (MNRE) updated guidelines on '**Waste to Energy**' and '**Biomass'** components of **National Bioenergy Programme (NBP).**

About NBP

- **Launched**: In 2022
- **Implementation**: Two phases; total budget of Rs. 1715 Crore; **Phase-1 (2021-22 to 2025-26)**.
- **Objective**: Utilize **surplus biomass** (from rural areas) for **power generation** and providing **additional source of income for rural households.**
- **Central Financial Assistance (CFA):** To project developers on various aspects of projects.
  - For **special categories** like North East Region, hilly states, SC/ST beneficiaries, etc., **20% more CFA** will be provided.
- **3 components of Programme**
  - **Waste to Energy Programme:** Support projects for **generating Biogas, BioCNG, Power, or Syngas** from urban, industrial, and agricultural waste/residues.
  - **Biomass Programme:** Support Biomass Briquette/Pellet manufacturing plants and Biomass (non-bagasse) based cogeneration projects.
  - **Biogas Programme:** Support biogas plants for clean cooking fuel, small power needs, improved sanitation, women empowerment, etc.

Key Features of Revised Guidelines	
Waste to Energy Programme • **Simplified Processes:** Easier approvals for MSMEs and industry. • **Improved CFA Disbursal**: Two-Stage Release:	**Biomass Programme** • **Simplified Processes:** No clearance documents needed for briquette/pellet plants.

○ **50% CFA** after consent from **State Pollution Control Board**, with bank guarantee. ○ Remaining CFA **after 80% capacity achievement** or maximum limit. (lower of two). • **Other: Streamlined inspections,** flexible & performance-based funding, etc.	• **Tech Integration: E.g.,** enabling use of IoT-based monitoring solutions. • **Stubble Burning Support:** Pellet producers in NCR and nearby states can choose MNRE or Central Pollution Control Board (CPCB) scheme. • **Other**: Flexible market access, performance-based subsidy, etc.

Bioenergy and its status in India

- Bioenergy is a **source of energy from organic material** that makes up plants, known as **biomass (e.g. wood, dung or charcoal).**
- **Modern bioenergy** involves processed biomass and advanced technologies to produce **cleaner and more efficient energy.** e.g. liquid biofuels, biogas, etc.
- **Total Installed capacity:** 11.6GW (Nov. 2025)
- Modern bioenergy today accounts for **13% of India's total final energy consumption** and is expected to grow by up to 45% between 2023 and 2030.

Key challenges in Bioenergy production

- **Competing uses of biomass resources**, affecting feedstock availability for bioenergy projects.
- **Supply chain and logistics bottlenecks** in feedstock transportation and processing.
- **Fragmented biomass markets** and absence of a dedicated biomass exchange/trading platform, making procurement difficult.
- **Limited private investment** and access to affordable finance due to high perceived project risk.
- **Lack of standardized contractual frameworks** e.g., long-term steam supply and biomass procurement agreements
- **Limited commercialization of biomass technologies** for large-scale deployment.

Other Initiatives taken for Bioenergy promotion

- **National Policy on Biofuels (2018, Revised 2022): Sets various targets e.g.** 5% biodiesel blending by 2030, 20% ethanol blending in petrol (E20) by 2025/26.
- **Pradhan Mantri JI-VAN Yojana:** financial support for advanced biofuels projects.
- **SATAT (Sustainable Alternative Towards Affordable Transportation) Initiative, GOBAR-Dhan Scheme (Galvanizing Organic Bio-Agro Resources).**

Way Forward

- **Creation of a National Biomass Repository and GIS-based biomass mapping** to provide reliable, publicly accessible data on biomass availability.
- **Development of organized biomass supply chains** through aggregation centres, biomass depots and farmer-producer organizations (FPOs).
- **Financial incentives and viability gap funding** to attract private investment in bioenergy projects.
- **Encouraging decentralized bioenergy projects** near feedstock sources to reduce transportation costs and improve rural incomes.
- **Support for research, innovation and commercialization of advanced bioenergy technologies**, including waste-to-energy and compressed biogas (CBG).

Conclusion

India has added **2,362 MW of biomass** and **228 MW of waste-to-energy capacity** in the last 10 years along with installing 2.88 lakh biogas plants in the country showing tremendous progress.

4.5. ETHANOL BLENDING

Why in the news?

India achieved 20% Ethanol Blending in Petrol **Five Years Ahead of Schedule.**

About Ethanol Blended Petrol (EBP) Programme

- **Genesis:** Launched in **2003** to promote **blending of ethanol in petrol.**
- **Target: National Policy on Biofuels (2018),** amended in 2022, advanced target of **20%** blending of ethanol in petrol to **2025-26** from **2030.**
    - The Policy allows use of Sugarcane Juice, Sugar Beet, Cassava, Damaged food grains, Rotten Potatoes, unfit for human consumption, Surplus food grains for ethanol production.

About Ethanol Blending

- It refers to the process of mixing ethanol with petrol to create a more sustainable and cleaner burning fuel.
- **Types of Ethanol: 1st Generation (**made from food crops such as cereals (rice, wheat etc.), sugarcane, sugar beet etc.); **2nd Generation** (from ligno-cellulosic or woody biomass, or agricultural residues/waste such as wheat straw, corn stover, wood etc.)**; 3rd Generation Ethanol** (derived from aquatic biomass such as algae); **4th Generation Ethanol** (from engineered plants and microorganisms).
- **Types of ethanol blended fuels:** E10 (10% Ethanol by Volume), E20 (20% Ethanol), E85 fuel (80-85% ethanol by volume), E100.
- **Achievements:**
    - **E20 target** achieved **in 2025** (5 years ahead of initial schedule).
    - **E85 rolled out** across several retail outlets of Public Sector OMCs.

Significance of Ethanol Blending

- **Reduce Crude Oil Import Dependence:** EBP program saved India ₹1.84 lakh crore in foreign exchange since ESY 2014-15.
- **Annadatas to Urjadata:** EBP has added ₹1.58 lakh crore earnings to farmers.
- **Reduced Emissions: Sugarcane and maize-based ethanol** reduce GHG emissions by **65% and 50%**, respectively, compared to petrol (NITI Aayog Study).
- **High-Octane Fuel:** With an octane rating of **100–105,** ethanol offers **better combustion efficiency and is suitable for high-performance engines.**
- **Cheaper alternative:** E.g., E85 is priced nearly ₹20 per litre lower than conventional petrol

Key concerns regarding ethanol blended fuels

- **Exacerbate food insecurity**, due to over diversion of food crops for ethanol production.
- **Environmental impacts,** e.g., Ethanol blending is heavily dependent on Sugarcane in India, a water intensive crop.
- **Vehicle related issues** like high Cost for modifications in engine design and fuel systems; marginal decrease in mileage; risk of clogging and fuel system failures etc.
- **Supply issues** like non-availability of feedstock industries; high cost of logistics; need for **storage infrastructure** etc.

Measures taken to boost Ethanol Blending Programme

- **PM JIVAN (Jaiv Indhan- Vatavaran Anukool fasal Awashesh Nivaran) Yojana:** For providing financial support to integrated bio-ethanol projects for setting up Second Generation (2G) ethanol projects
- **Ethanol Interest Subvention Schemes (EISS)** launched to foster the establishment of Dedicated Ethanol Plants (DEPs).
- **GST on Ethanol lowered from 18% to 5% (2018).**
- **Industries (Development and Regulation) or IDR Act** amended in 2016 to clarify on the roles of Central and State Government for continuous supply of ethanol to be blended with petrol.
- **Approved regulations for E100 fuel**.
- **Central excise duty exemptions** to petrol blended with **22%, 25%, 27% and 30% ethanol.**

Conclusion

India's ethanol journey has been unstoppable offering a win-win solution for **clean fuel, pollution control, and farmer income** with remarkable growth in maize based ethanol from 0% (2021-22) to 42% (2025).

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DAKSHA MAINS MENTORING PROGRAM 2027

DAKSHA MAINS MENTORING PROGRAM 2027

(A Strategic Revision, Practice, and Enrichment Mentoring Program for Mains Examination 2027)

DATE 5 JUNE
DURATION 5 MONTHS

HIGHLIGHTS OF THE PROGRAMME

- Highly experienced and qualified team of mentors
- Scheduled group sessions for strategy discussions, live practice, and peer interaction
- Well-structured revision and practice plan for GS Mains, Essay & Ethics
- Access toDaksha Mains Practice Tests
- Emphasis on score maximization and performance improvement
- Personalized one-to-one sessions with mentors
- Subject-wise strategy documents based on thorough research
- Continuous performance assessment, monitoring and smart interventions

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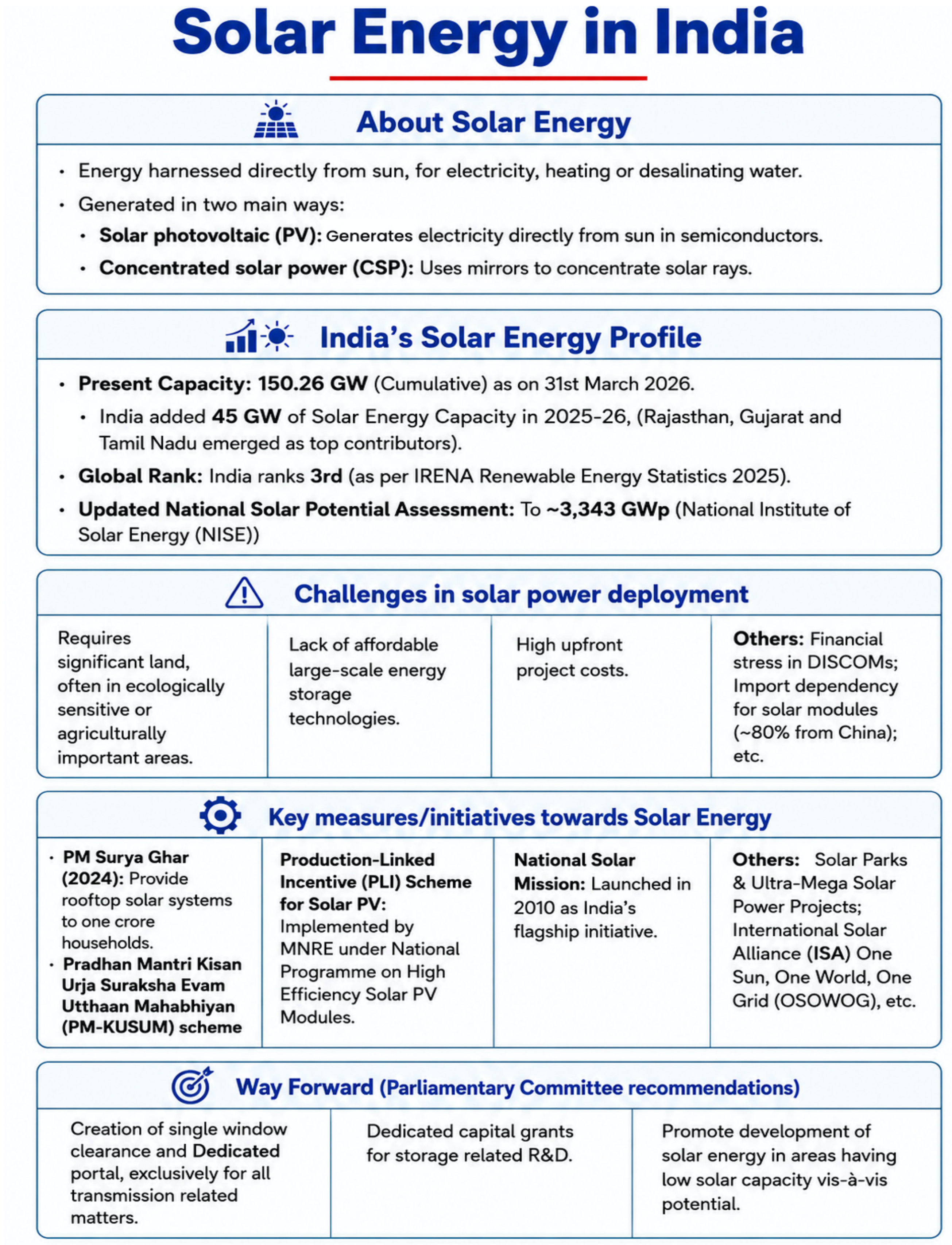
4.6. SOLAR ENERGY IN INDIA AT A GLANCE



Solar Energy in India

About Solar Energy

- Energy harnessed directly from sun, for electricity, heating or desalinating water.
- Generated in two main ways:
    - **Solar photovoltaic (PV):** Generates electricity directly from sun in semiconductors.
    - **Concentrated solar power (CSP):** Uses mirrors to concentrate solar rays.

India's Solar Energy Profile

- **Present Capacity: 150.26 GW** (Cumulative) as on 31st March 2026.
    - India added **45 GW** of Solar Energy Capacity in 2025-26, (Rajasthan, Gujarat and Tamil Nadu emerged as top contributors).
- **Global Rank:** India ranks **3rd** (as per IRENA Renewable Energy Statistics 2025).
- **Updated National Solar Potential Assessment:** To **~3,343 GWp** (National Institute of Solar Energy (NISE))

Challenges in solar power deployment

- Requires significant land, often in ecologically sensitive or agriculturally important areas.
- Lack of affordable large-scale energy storage technologies.
- High upfront project costs.
- **Others:** Financial stress in DISCOMs; Import dependency for solar modules (~80% from China); etc.

Key measures/initiatives towards Solar Energy

- **PM Surya Ghar (2024):** Provide rooftop solar systems to one crore households.
- **Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) scheme**

Production-Linked Incentive (PLI) Scheme for Solar PV: Implemented by MNRE under National Programme on High Efficiency Solar PV Modules.

National Solar Mission: Launched in 2010 as India's flagship initiative.

Others: Solar Parks & Ultra-Mega Solar Power Projects; International Solar Alliance **(ISA)** One Sun, One World, One Grid (OSOWOG), etc.

Way Forward (Parliamentary Committee recommendations)

- Creation of single window clearance and **Dedicated** portal, exclusively for all transmission related matters.
- Dedicated capital grants for storage related R&D.
- Promote development of solar energy in areas having low solar capacity vis-à-vis potential.

4.6.1. INTERNATIONAL SOLAR ALLIANCE (ISA)

Why in the News?

On March 11, 2026, **International Solar Alliance (ISA) celebrated its 10th Foundation Day**.

About ISA

- Jointly launched by **India and France** in **2015** on sidelines of **UN Climate Change Conference (CoP21) in Paris.**
- First international inter-governmental organization **headquartered in India.**
- **Objective:** Towards **1000 strategy to unlock US$ 1 trillion in low-cost solar investment by 2030,** providing **clean energy access to 1 billion people, mitigate 1 billion tonnes of CO_2 emissions** annually.
- **Initiatives under ISA: OSOWOG** (One Sun, One World, One Grid); Solar Technology Application Resource Centre (STAR-C) initiative, etc.
    - Recently, **ISA launched global AI for Energy Mission** for India AI Impact Summit 2026 to fast track adoption of AI in clean energy systems across its 120+ countries.

Key Achievements

- **Membership expanded to 125 countries**; India re-elected as President (2024-26).
- Successful **institutionalization with focus on catalytic finance**, **capacity building** (STAR-C), and **innovation** (SolarX).
- Operationalization of **Global Solar Facility** and **Viability Gap Funding** for LDCs (Least Developed Countries) and SIDS (Small Island Developing States).
- Promotes **South-South Cooperation** among sunshine countries (Global South) for solar energy access, technology, and finance.

Significances of ISA

- **Alternative Energy Architecture:** Indian PM envisioned ISA as an **"alternative OPEC,"** offering a platform for the equitable production, breaking monopoly of fossil-fuel-rich nations.
- **Climate Change Mitigation:** Critical role in achieving **SDG 7 for clean energy and SDG 13 for climate action**.
- **South-South Cooperation:** Serves as a vital diplomatic tool to give a voice to developing, energy-deficient nations (Global South) on the international stage.
- **Financial & Tech Aggregation:** Aggregates global demand to reduce cost of solar finance and technologies for Least Developed Countries (LDCs) and Small Island Developing States (SIDS).

Challenges before ISA

- **Financial**: Ambitious "Towards 1000 Strategy" ($1 trillion investment by 2030) **faces financing gaps**.
- **Geopolitical challenges:** E.g., US exit in 2026 highlights vulnerability to great power politics.
- **Implementation gaps:** In project execution, especially in Africa and small island nations.
- **Trade and Tariff Barriers:** High Most Favoured Nation (MFN) tariffs on solar photovoltaic (PV) cells and modules, especially in African and Pacific island nations hinder deployment.
- **"Solar Constancy Problem"**: Lack of sunlight at night or during bad weather/pollution necessitates advanced energy storage technologies.
- **Lack of Domestic Manufacturing:** Many developing countries lack the technical capacities, quality infrastructure, and policies.

Conclusion

ISA represents a transformative movement toward a sustainable and democratic global energy future, rooted in Indian philosophy of **Vasudhaiva Kutumbakam** (the world is one family).

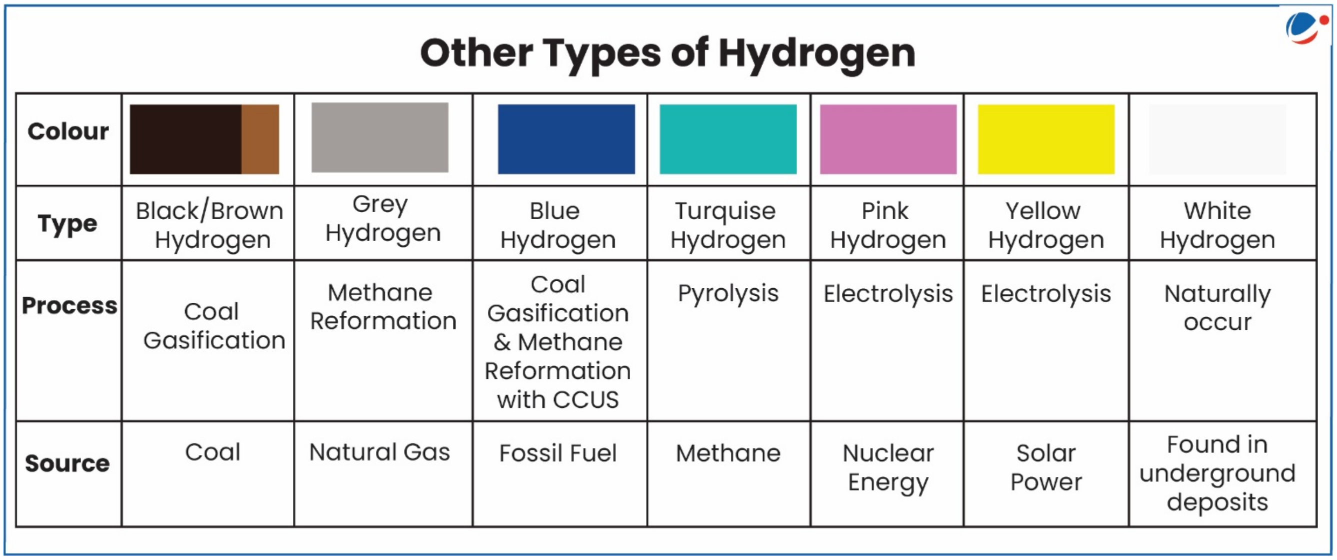
4.7. HYDROGEN ENERGY

Why in the news?

Recently Indian Railways Successfully Tested **Nation's First Hydrogen-Powered Coach** at Integral Coach Factory.

About Green Hydrogen

- Refers to hydrogen produced through **electrolysis splitting water molecules** (H_2O) into hydrogen and oxygen using electricity from renewable sources like solar, wind etc.
  - It is also produced with the help of gasification of biomass.



Other Types of Hydrogen

Colour	⬛🟫	▨	🟦	🟦	🟪	🟨	⬜
Type	Black/Brown Hydrogen	Grey Hydrogen	Blue Hydrogen	Turquise Hydrogen	Pink Hydrogen	Yellow Hydrogen	White Hydrogen
Process	Coal Gasification	Methane Reformation	Coal Gasification & Methane Reformation with CCUS	Pyrolysis	Electrolysis	Electrolysis	Naturally occur
Source	Coal	Natural Gas	Fossil Fuel	Methane	Nuclear Energy	Solar Power	Found in underground deposits

Applications of Green Hydrogen

- **Industry: Steel production (**Replacing coking coal in blast furnaces), **Refineries and fertiliser plants (**Substitute for fossil fuel-based hydrogen in ammonia and methanol production) etc.
- **Transport:** Trucks, buses etc. using hydrogen fuel cells.
- **Energy storage and Grid balancing:** Generates electricity during peak demand/low renewable generation.

Benefits of Hydrogen as an Alternative Fuel

- **Green hydrogen has a higher energy density than batteries**; can be stored/transported in large quantities.
- **Hydrogen fuel-cell trains emit only water vapor (zero direct CO_2 emissions):** Replacing one diesel train with hydrogen can cut roughly equivalent to the annual CO_2 output of 400 cars.
- **Green hydrogen production** has lower infrastructure requirements.

Challenges in Adopting Hydrogen as an Alternate Fuel

- Most of hydrogen produced in the country comes from **steam methane reforming (Grey Hydrogen).**
- **High Production costs** of Green Hydrogen (roughly $4-5 per kg).
- **Substantial energy and cost in extraction** and non-economical battery storage.
- **Huge investments** required to establish a robust supply chain.
- **Storage and safety concerns** like flammability.
- **Green Hydrogen production requires up to 9 litres of water** per kg of hydrogen.

Initiatives

- **National Green Hydrogen Mission:** Targets Production of **5 MMT per annum** of Green Hydrogen **by 2030**.
  - **Duration:** Phase I (2022-23 to 2025-26) and Phase II (2026-27 to 2029-30).

  - **Key components**: **Strategic Interventions for Green Hydrogen Transition (SIGHT)** programme, **Pilot Projects** for steel, mobility, shipping, etc., Development of Green Hydrogen Hubs etc.
  - **Recent initiatives**: Green Hydrogen Certification Scheme of India

Other Key developments related to Green Hydrogen in India

- Ministry of Steel inaugurated **India's 1st Green Hydrogen Plant** in the **stainless-steel sector.**
- Gail initiated **blending 2% hydrogen in CNG networks** and 5% in PNG networks in Indore.
- NTPC introduced **Hydrogen based Fuel cell electric vehicle (FCEV)** buses in Leh.
- **Indigenously Built Green Hydrogen Power Plant (GHPP)** producing ~ **140 metric tonnes of green hydrogen** Commissioned at Kandla Port.
- India's **First Indigenous Hydrogen Fuel Cell Passenger Vessel** began in Varanasi using indigenous Low Temperature Proton Exchange Membrane (LT-PEM) fuel cell.

Way Forward

- **Achieving economies of scale** by creating demand in sectors like transportation, industry and power generation.
- Scaling up **green hydrogen production** and fostering research.
- **Developing efficient storage** and distribution networks.

Conclusion

Deploying Hydrogen as **alternative fuel** shows **broader commitment to innovation, energy efficiency, environmentally sustainable transportation** and supporting India's net-zero carbon emission goals.

4.8. NATIONAL POLICY ON GEOTHERMAL ENERGY

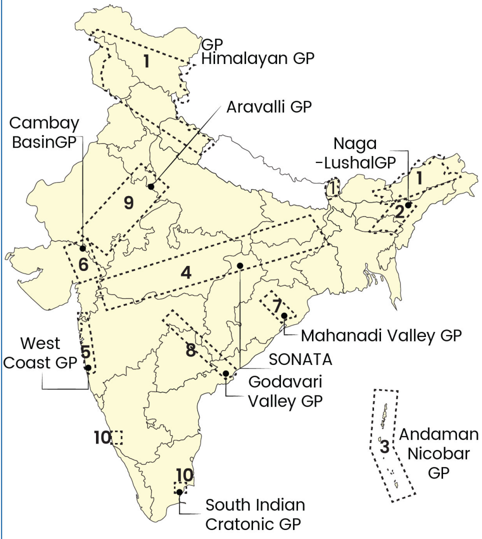
Why in the News?

Ministry of New & Renewable Energy (MNRE) notified **National Policy on Geothermal Energy (2025),** India's first such Policy to reinforce efforts for an energy transition.

About Geothermal Energy

- It harnesses heat stored within the Earth's crust.
- **Key Sources and applications-**
  - **High-enthalpy (~200°C) resources:** Volcanic regions, geysers and hot springs suitable for electricity generation.
  - **Low- to medium-enthalpy (100–180°C) resources:** Hot rocks and shallow ground layers suitable for **direct-use applications** like heating and cooling, agri-food, aquaculture, etc.
- **Estimated Potential in India:** 10,600 MW (Geothermal Atlas of India, 2022)
  - GSI identified 381 hot springs and 10 geothermal provinces (see infographic)
- **Significance of Geothermal Energy**
  - **Renewable:** Inexhaustible energy from Earth's heat
  - **Clean:** 95% lower emissions than fossil fuels.
  - **Reliable:** 24/7 operation; Perfect baseload power.
  - **Economic:** Reduces imports, creates jobs, etc.

India's Geothermal Provinces (GPs)



Note: Provinces 1, 2, and 3 are orogenic, while Provinces 4 to 10 are non-orogenic.

Challenges related to development of Geo Thermal Energy in India

- **High Upfront Cost: Exploration and drilling** are capital intensive.

- **Exploration & Data Gaps:** Limited deep drilling assessment and data with geological complexity (Himalayas, volcanic zones).
- **Lack of Commercial Projects**: Only one 20 kW pilot plant (Manuguru, Telangana) exists, no utility-scale projects yet.
- **Others:** High investment risk; lack of indigenous drilling and reservoir management, environmental and social concerns, etc.

About National Policy on Geothermal Energy (NPGE, 2025)

- **Vision**: Establish Geothermal Energy as **major pillar of India's renewable energy mix, achieving net zero carbon emission by 2070.**
- **Nodal Ministry for implementation of GE based projects:** MNRE
- **Goals of NPGE, 2025:** Improve research; Collaborate with key stakeholders; Deploy geothermal heating and cooling solutions, building enabling ecosystem.

Key features of the Policy

- **Scope of policy:**
    - **Geothermal Resource Assessment**, **Power Production systems,** Direct use, Ground (geothermal) Source Heat Pump (GSHP) etc.
    - **Emerging Innovative Technologies** like Enhanced Geothermal Systems (EGS), Advanced Geothermal Systems (AGS), etc.
    - **Extracting GE from abandoned oil and gas wells**.
- **Geothermal resource data repository:** Through Intergovernmental/inter-agency collaboration.
- **Developmental Model:** Preference to indigenous geothermal technologies; economic feasibility models like revenue sharing; Central funding assistance to Northeastern region and special category states, etc.
- **Financing Mechanisms: Renewable Energy Research and Technology Development Programme (RE-RTD)** provides up to 100% financial support to Government/non-profit research organizations and upto 70% to Industry, start-ups, private Institutes, entrepreneur, and manufacturing units.

Conclusion

With mechanisms for local innovation, stakeholder consultation, and dedicated pilot projects, the policy creates a strong foundation for sustainable, reliable geothermal growth.

4.9. UNDERGROUND COAL GASIFICATION (UCG)

Why in the news?

Government released **Draft Guidelines for Underground Coal Gasification (UCG)** concerning preparation of mining and mine closure plans for UCG blocks.

About Coal Gasification

- A **thermochemical process** that converts coal into **syngas** — a mixture of **carbon monoxide (CO), hydrogen (H_2), carbon dioxide (CO_2), methane (CH_4)** and other gases.
    - It involves **partial oxidation at high temperature and pressure** often integrated with carbon capture and storage technology to reduce CO_2 emissions.
- **Significance**: Enhances **energy security**, offers **cleaner alternative to traditional combustion** with **lower sulfur emissions; produces syngas for use in power generation, methanol, etc.**

Challenges for Coal Gasification Technology

- **High Project Costs:** Requires **heavy upfront investment** in gasifiers, CO_2 capture, and processing.
- **Technology Adoption:** Global technologies **suit low-ash coal,** making adaptation to India's high-ash coal technically complex and expensive.
- **Uncertain Coal Supply:** Inconsistent coal quality and **absence of assured long-term supply agreements.**

- **Input Costs:** Combined expense of coal, oxygen, and water makes domestic gasification **costlier.**

Major Initiative taken

- **National Coal Gasification Mission (Ministry of Coal)** to gasify 100 Million Tonnes (MT) of coal **by 2030.**
- **Coal Gasification Incentive Scheme** to promote coal and lignite gasification projects in public and private sectors.

Way Forward

- Advancing to **Commercial scale** to ensure long term viability.
- Promoting Sustainability involving **integration of Carbon Capture, Utilization and Storage for reducing emissions.**
- Policy Push through **Viability Gap Funding**, assured coal supply, dedicated auction mechanism, etc.
- Technology Fit using **circulating fluidized bed gasification** leveraging India's high ash coal characteristics.

Conclusion

Coal gasification is a key transformative technology and will be pivotal in **strengthening India's energy security, reducing import dependence, and supporting industrial growth**.

4.10. WIND ENERGY

Why in the news?

India's Wind Energy Capacity rose over 10.5% from May 2024.

About status of wind energy in India

- **Global status:** India has **4th largest wind power installed capacity.**
- **Significant growth**: From **21.04 GW in 2014** to **56 GW (2026).**
- **Role in Renewable Energy Mix:** Wind is second-largest contributor following solar.
- **Highest potential states:** Gujarat, Maharashtra, Karnataka, Tamil Nadu, Rajasthan, Andhra Pradesh, etc.

About Offshore Wind Energy

- **Meaning:** Use of **wind turbines** to generate **electricity in bodies of water** like **oceans or large lakes.**
- **Advantages of Offshore Wind over Onshore Wind Energy**
  - **More energy**: Offshore turbines generate 1MW more energy than onshore turbines **due to larger turbines**.
  - **Efficiency**: Winds at sea are **stronger** and often blow in the **same direction.**
  - **No land requirement: Land acquisition issue** absent with no discomfort to locals.
- **Challenges of Offshore Wind Energy**
  - **High Capital Costs** for installation.
  - Exposure to harsh marine conditions like saltwater corrosion, etc.
  - Underwater operational noise **can affect marine fauna and ecosystems.**

Issues involved in wind power in India

- **Infrastructure Limitations:** Causes grid instability, Inadequate transmission infrastructure, lack of mechanism for power evacuation etc.
- **Economic Factors:** Minimum Project Size is very high, High investment Costs and Financial risks due to fluctuating tariffs.
- **Technical Challenges:** Complex Installation and Commissioning, Transportation of equipment in remote areas and Maintenance and Operations.

Government Initiatives to Wind Energy

- **Centralized Data Collection and Coordination (CCDC) Wind Initiative:** It aims to improve wind resource assessment helping **identify the most promising locations for wind energy projects**.

- **National Wind-Solar Hybrid Policy, 2018:** To provide a framework for promotion of large grid connected wind-solar photovoltaic hybrid systems for optimal and efficient utilization.
- **Viability Gap Funding (VGF) for offshore wind energy projects:** In line with the National Offshore Wind Energy Policy, 2015; India-UK Taskforce for offshore wind energy launched.
- **Other:** Green Energy Open Access Rules (2022), Renewable Energy Purchase Obligation (RPO), etc.

Conclusion

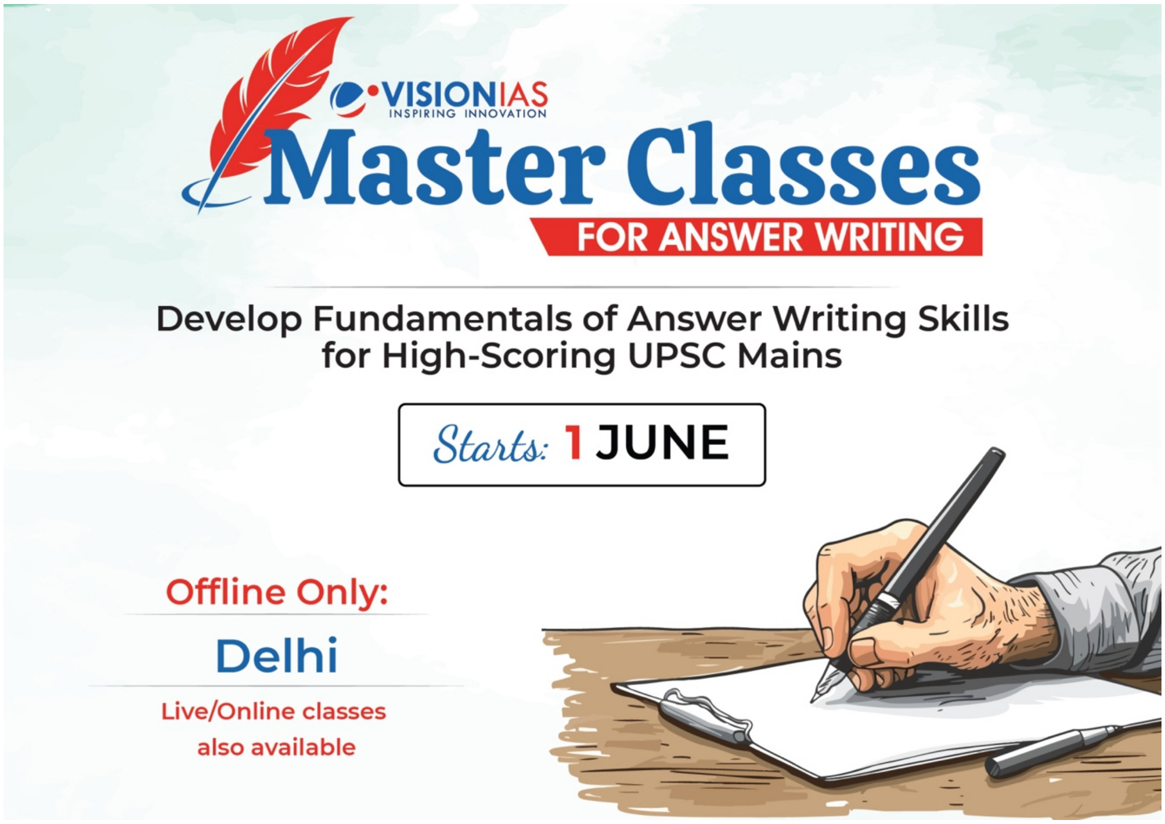
India's **extensive onshore and offshore wind resources** provide a strong foundation **for long-term growth,** and requires **faster project execution, stronger transmission infrastructure, improved forecasting capabilities, and continued policy support.**

4.11. KEYWORDS

Energy Transition	Bioenergy	Waste-to-Energy	Ethanol Blending
Geothermal Energy	International Solar Alliance	Green Hydrogen	Alternate Fuels
Offshore Wind Energy	Coal Gasification	Energy Storage	Electric Mobility

4.12. PRACTICE QUESTION

<table>
<tr><td colspan="4">Ethanol Blending in Petrol is gaining a lot of traction in India and elsewhere. In this regard, mention the key benefits and challenges associated with Ethanol Blending in petrol.</td></tr>
<tr><td>Introduction</td><td>Body Part 1</td><td>Body Part 2</td><td>Conclusion</td></tr>
<tr><td>Mention India's recent achievement of Ethanol Blending Target under Ethanol Blending Programme.</td><td>Mention in one line about Ethanol and suggest its key benefits.</td><td>Discuss challenges associated with Ethanol Blending.</td><td>Provide a way forward balancing both the benefits and challenges.</td></tr>
</table>



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5. CONSERVATION EFFORTS

5.1. INTERNATIONAL TREATIES AND CONVENTIONS

5.1.1. NATIONAL REPORT BY INDIA ON CONVENTION ON BIOLOGICAL DIVERSITY

Why in news?

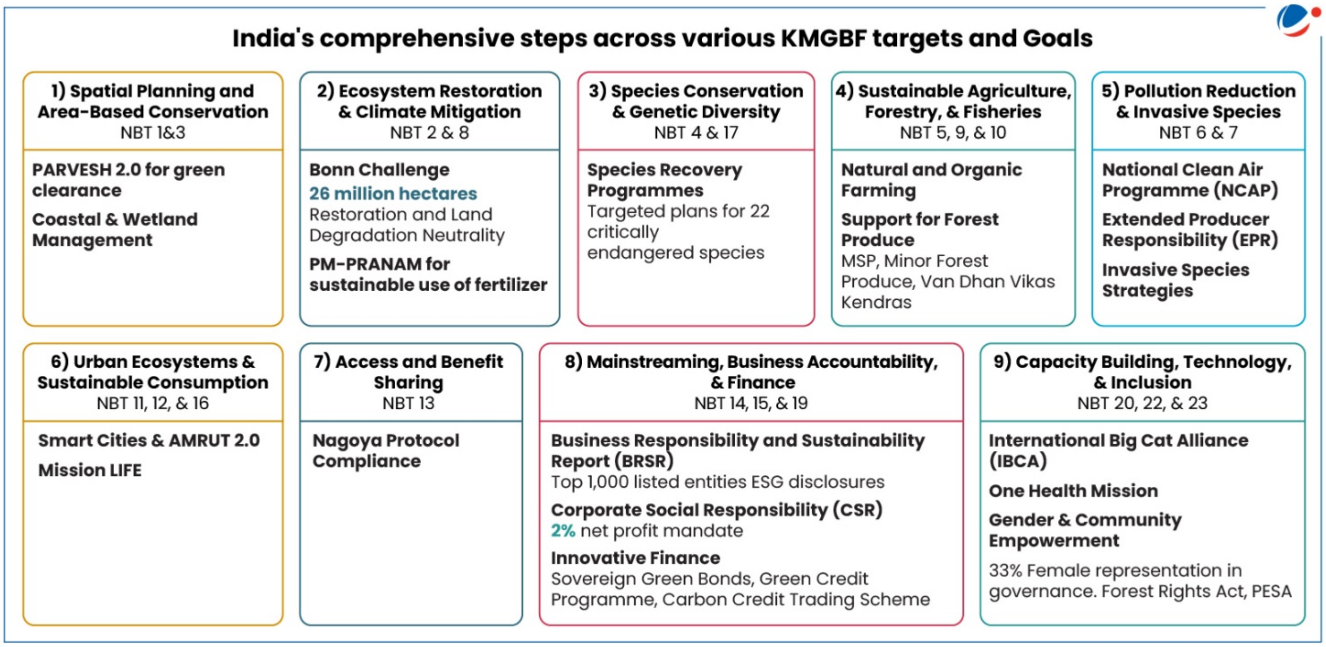
Ministry of Environment, Forest and Climate Change (**MoEFCC**), submitted **7th National Report under article 26** of Convention on Biological Diversity **(CBD)** (**mandatory** obligation under CBD).

About United Nations Convention on Biological Diversity (UNCBD)

- International **legally binding treaty** adopted at **United Nation's Conference on Environment and Development (UNCED), Earth Summit, Rio de Janeiro, Brazil** in 1992.
  - **Enforced in 1993** and operates under **United Nations Environment Programme (UNEP).**
- **Objectives:** Conservation of biological diversity**;** Sustainable use of its components**;** Fair and equitable sharing of the benefits arising out of utilization of genetic resources
- **Protocols:** Cartagena Protocol on Biosafety (safe handling, transport and use of Living Modified Organisms); Nagoya-Kuala Lumpur Supplementary Protocol; Nagoya Protocol on Access and Benefit Sharing.
- **Targets:** In 2022, **Kunming-Montreal Global Biodiversity Framework (KMGBF)** replaced Aichi Biodiversity Targets. **Key targets**
  - **30 by 30 target**: 30% conservation of land, sea, and inland water and 30% restoration of various degraded ecosystems by 2030.
  - **Financing Target**: Developed countries to provide developing countries at least $20 bn/ year by 2025, and $30 bn/ year by 2030.

Key Highlights of the Report: Progress against 23 National biodiversity Targets (NBT) under updated National Biodiversity Strategy and Action Plan (NBSAP) (2024–30)

- **All 23 revised NBSAP targets (142 indicators) are on track** and align with KMGBF.
- **Forest and tree cover increased** to 25.17% of geographical area.
  - Forest carbon stock reached 7,285.5 million tonnes (55% is soil organic carbon).
- **24.1 million hectares (mha) restored or under restoration.**
  - India is nearing its Bonn Challenge pledge of 26 mha by 2030.
- **100 Ramsar sites** as of Jun 2026 (26 in 2014). (Ranks 1st in Asia and 3rd globally).
- **Wildlife Populations:** 3,682 Tigers (>70% of global total), 22,446 Elephants, >4,000 Rhinos, and 891 Asiatic Lions.
  - **First Assessments:** Recorded 718 Snow Leopards and 6,327 Riverine Dolphins.
- **Protected Areas covers 5.71%** of land area; marine protected areas have also increased.



India's comprehensive steps across various KMGBF targets and Goals

1) Spatial Planning and Area-Based Conservation
NBT 1&3
- **PARVESH 2.0 for green clearance**
- **Coastal & Wetland Management**

2) Ecosystem Restoration & Climate Mitigation
NBT 2 & 8
- **Bonn Challenge** **26 million hectares** Restoration and Land Degradation Neutrality
- **PM-PRANAM for sustainable use of fertilizer**

3) Species Conservation & Genetic Diversity
NBT 4 & 17
- **Species Recovery Programmes** Targeted plans for 22 critically endangered species

4) Sustainable Agriculture, Forestry, & Fisheries
NBT 5, 9, & 10
- **Natural and Organic Farming**
- **Support for Forest Produce** MSP, Minor Forest Produce, Van Dhan Vikas Kendras

5) Pollution Reduction & Invasive Species
NBT 6 & 7
- **National Clean Air Programme (NCAP)**
- **Extended Producer Responsibility (EPR)**
- **Invasive Species Strategies**

6) Urban Ecosystems & Sustainable Consumption
NBT 11, 12, & 16
- **Smart Cities & AMRUT 2.0**
- **Mission LIFE**

7) Access and Benefit Sharing
NBT 13
- **Nagoya Protocol Compliance**

8) Mainstreaming, Business Accountability, & Finance
NBT 14, 15, & 19
- **Business Responsibility and Sustainability Report (BRSR)** Top 1,000 listed entities ESG disclosures
- **Corporate Social Responsibility (CSR)** **2%** net profit mandate
- **Innovative Finance** Sovereign Green Bonds, Green Credit Programme, Carbon Credit Trading Scheme

9) Capacity Building, Technology, & Inclusion
NBT 20, 22, & 23
- **International Big Cat Alliance (IBCA)**
- **One Health Mission**
- **Gender & Community Empowerment** 33% Female representation in governance. Forest Rights Act, PESA

Key Challenges in Biodiversity Management

- **Limited Progress Clarity**: Report identifies only NBT-1 biodiversity-inclusive land and sea-use planning and NBT-2 are identified as being on track.
- **Land Degradation**: ~ 29.77% of India's area is currently undergoing degradation.
- **Stagnant Coastal Planning:** 3/13 coastal States approved Integrated Coastal Zone Management Plans (FY 2020–24).
- **Data collection issues:** Fragmented data across ministries etc.
- **Others: Invasive Species Expansion especially** in tiger ranging state eg. **Chromolaena odorata** recorded rise of 70%; Data collection issues, etc.

Conclusion

India's **7th National Report to CBD** underscores a nation making significant strides toward its global **environmental commitments** yet simultaneously grappling with complex domestic realities.

5.1.2. UN 'HIGH SEAS' TREATY

Why in the News?

Treaty for Conservation and Sustainable Use of Marine Biological Diversity of Areas Beyond National Jurisdiction **(BBNJ agreement)** or **High Seas Treaty** was enforced after ratification by 60th country.

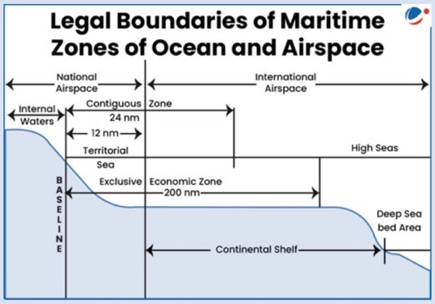
About BBNJ Agreement

- **Aim: Conservation and sustainable utilisation of marine biological diversity** in areas beyond national jurisdiction, **i.e. area beyond economic exclusive zone**.
- **International treaty under United Nations Convention on the Law of the Sea** (UNCLOS).
    - The BBNJ Agreement will be the third implementation agreement under UNCLOS, apart from
        - 1994 Part XI Implementation Agreement and 1995 UN Fish Stocks Agreement are other two.
    - **India signed the treaty but not ratified yet.**
- **Key Pillars of the Treaty**: Marine Protected Areas (MPAs); Marine Genetic Resources (MGRs); Capacity Building and Transfer of Marine Technology; Environmental Impact Assessment, etc.

- **Exceptions to agreement**
    - **Any warship**, military aircraft or naval auxiliary.
    - **Fishing and fishing-related activities** regulated under international law.
    - Utilization of MGRs and their digital sequence information **do not apply to Party's military activities.**

United Nations Convention on the Law of the Sea (UNCLOS)

- **Often called "Constitution of Ocean,"** primary international treaty governing use of seas and oceans.
    - Adopted in **1982**, enforced in **1994**.
- **State Parties:** 171 State parties (including India).
- Seabed beyond national jurisdiction is **"common heritage of mankind"**, managed by **International Seabed Authority (ISA).**
- **Dispute Settlement: International Tribunal for Law of Sea (ITLOS).**



Significance of the Treaty

- **Fill Critical Gaps in Ocean Governance**, only about 1% of the high seas are currently protected.
- **To Promote Equity and Fairness,** especially for small Island nations like Vanuatu.
- **Strengthening Climate Resilience** based on polluter-pays principle.
- Acknowledges the importance of **Indigenous and Local Knowledge:**
- Supports **Sustainable Development Goal (SDG) 14**, **30x30** target, etc.
- **Significance for India:** Reinforces India's support for **UNCLOS,** complements India's Blue Economy and Deep Ocean Mission, etc.

Challenges

- **Lack of Universal Ratification:** Significant players like the U.S., China, India, are yet to ratify.
- **Conflict with National Interests:** Calls for setting up Marine Protected Areas (MPAs), which conflict with many states' territorial claims in disputed waters, such as the South China Sea.
- **Enforcement:** Does not establish its own punitive body, relies on individual countries for regulation.
- **Limited Scope:** Regarding technology transfer and capacity-building for low- and middle-income countries.

Way Forward

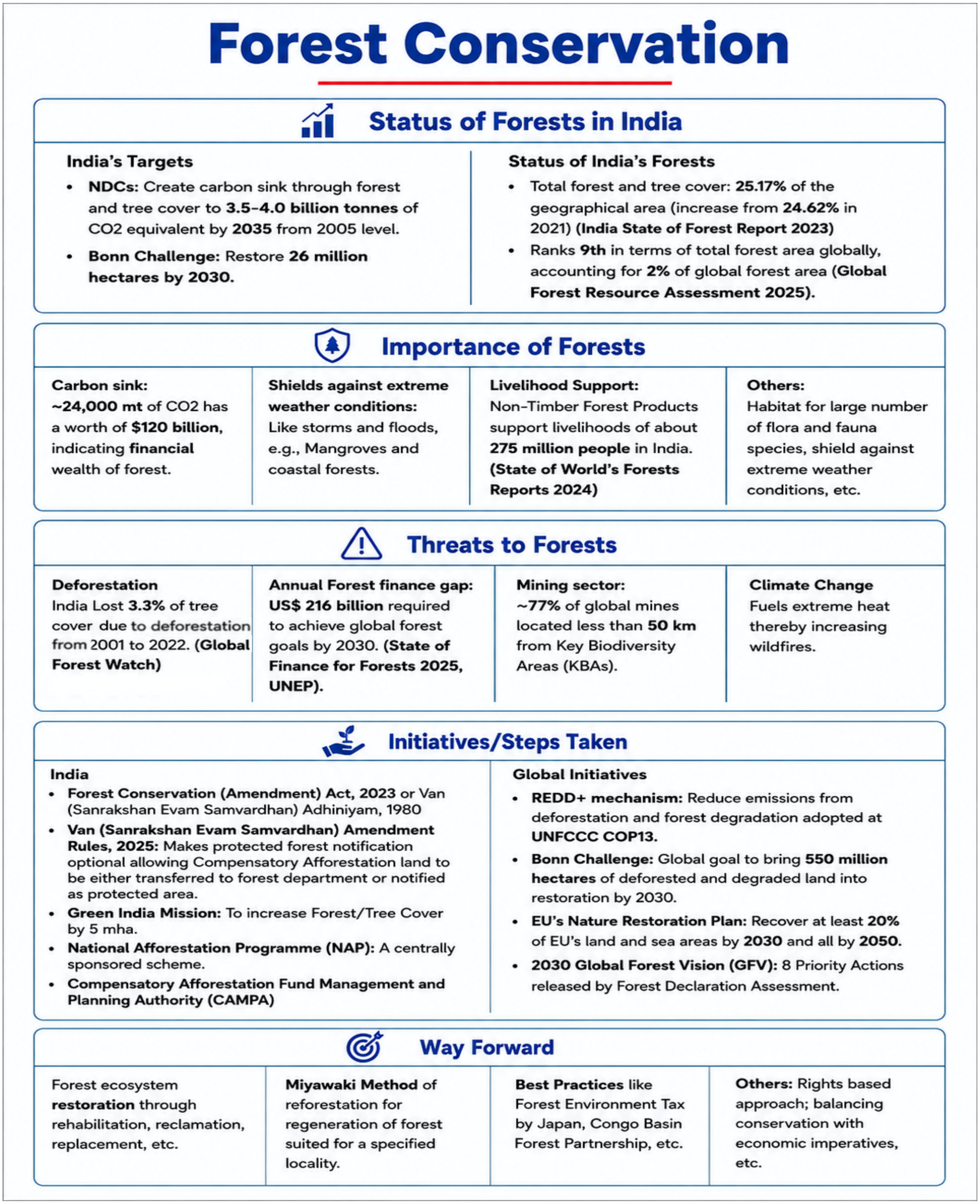
- **Encourage Ratification by major powers**: Use platforms like **UN General Assembly, G20, etc.**
- **Strengthening Enforcement Mechanisms: Global compliance, monitoring system** under UN.
- **Resolving National Interests Conflicts: Regional cooperation frameworks** (ASEAN for South China Sea or IORA for Indian Ocean) to harmonize MPAs with national claims.
- **Others:** Expand EIA to accidental activities like oil spills, support for developing countries through financial and technology transfer using GEF, GCF, etc.

Conclusion

The treaty sets precise mechanisms for sustainable use of **marine biological diversity** through **area-based management tools** and establishes rules for **conducting environmental impact assessments.**

5.2. FORESTS AND WILDLIFE CONSERVATION

5.2.1. FOREST CONSERVATION AT A GLANCE



Forest Conservation

Status of Forests in India

India's Targets

- **NDCs:** Create carbon sink through forest and tree cover to **3.5-4.0 billion tonnes** of CO2 equivalent by **2035** from 2005 level.
- **Bonn Challenge:** Restore **26 million hectares by 2030.**

Status of India's Forests

- Total forest and tree cover: **25.17%** of the geographical area (increase from **24.62%** in 2021) **(India State of Forest Report 2023)**
- Ranks **9th** in terms of total forest area globally, accounting for **2%** of global forest area **(Global Forest Resource Assessment 2025).**

Importance of Forests

Carbon sink: **~24,000 mt** of CO2 has a worth of **$120 billion,** indicating **financial** wealth of forest.

Shields against extreme weather conditions: Like storms and floods, e.g., Mangroves and coastal forests.

Livelihood Support: Non-Timber Forest Products support livelihoods of about **275 million people** in India. **(State of World's Forests Reports 2024)**

Others: Habitat for large number of flora and fauna species, shield against extreme weather conditions, etc.

Threats to Forests

Deforestation India Lost **3.3%** of tree cover due to deforestation from 2001 to 2022. **(Global Forest Watch)**

Annual Forest finance gap: **US$ 216 billion** required to achieve global forest goals by 2030. **(State of Finance for Forests 2025, UNEP).**

Mining sector: **~77%** of global mines located less than **50 km** from Key Biodiversity Areas (KBAs).

Climate Change Fuels extreme heat thereby increasing wildfires.

Initiatives/Steps Taken

India

- **Forest Conservation (Amendment) Act, 2023** or Van (Sanrakshan Evam Samvardhan) Adhiniyam, 1980
- **Van (Sanrakshan Evam Samvardhan) Amendment Rules, 2025:** Makes protected forest notification optional allowing Compensatory Afforestation land to be either transferred to forest department or notified as protected area.
- **Green India Mission:** To increase Forest/Tree Cover by 5 mha.
- **National Afforestation Programme (NAP):** A centrally sponsored scheme.
- **Compensatory Afforestation Fund Management and Planning Authority (CAMPA)**

Global Initiatives

- **REDD+ mechanism:** Reduce emissions from deforestation and forest degradation adopted at **UNFCCC COP13.**
- **Bonn Challenge:** Global goal to bring **550 million hectares** of deforested and degraded land into restoration by 2030.
- **EU's Nature Restoration Plan:** Recover at least **20%** of EU's land and sea areas by **2030** and all by **2050.**
- **2030 Global Forest Vision (GFV):** 8 Priority Actions released by Forest Declaration Assessment.

Way Forward

Forest ecosystem **restoration** through rehabilitation, reclamation, replacement, etc.

Miyawaki Method of reforestation for regeneration of forest suited for a specified locality.

Best Practices like Forest Environment Tax by Japan, Congo Basin Forest Partnership, etc.

Others: Rights based approach; balancing conservation with economic imperatives, etc.

5.2.2. COMPENSATORY AFFORESTATION (CA)

Why in the news?

Central Empowered Committee (CEC) files a report regarding management of CA Funds highlighting that India **achieved 85% of overall CA Target** between 2019-20 and 2023-24.

About Compensatory afforestation (CA)

- It means **afforestation done in lieu of the diversion of forest land** for non-forestry use (Like industrial or infrastructure development) under the **Forest (Conservation) Act, 1980.**

About Compensatory Afforestation Fund Act, 2016

- Originated from **SC's orders in TN Godavarman v. UoI (1995)**.
- Created **CA Fund Management and Planning Authority (CAMPA)** at National and State level.
- Provides for **CA funds** under public accounts of India and public accounts of each State.

Issues with Release of CA funds (Highlighted by CEC)

- Delay in **Annual Plan of Operation (APO)** submission,
- **Multiple Approvals at State Level** despite National Authority's clearance,
- **Understaffed CAMPA Offices**, and **Misuse of Funds** etc.

Recommendations of CEC

- **Strengthen Institutional Mechanisms:** Governing Body, Steering Committee, and Executive Committee of State CAMPA to meet on a regular basis.
- **Enhance Monitoring & Transparency:** Geo-tagging and online disclosure of CA sites on platforms, like e-Green Watch and PARIVESH 2.0, shall be mandated.
- **Other Recommendations:** Streamline Fund Flow, Ensure Timely APO Submission etc.

Conclusion

CA Funds help **boost restoration and enhancement of forest wealth, enhance bio-richness, water availability, creating additional carbon sink** and secure **ecological security** of India.

5.2.3. ARAVALLIS

Why in the News?

Supreme Court (SC) stayed its previous judgement concerning **definition** of Aravalli hills and range.

Background of the Issue

- **Formation of Expert Committee (May 2024): SC** directed Ministry of Environment, Forest and Climate Change to form **Expert Committee** to recommend **"uniform definition"** for Aravallis.
- **Definition Adoption (November 2025):** In **T.N. Godavarman Thirumulpad Case (1995),** SC **accepted** Committee recommendations of **uniform definition** and paused grant of fresh mining leases**.**
    - **Definition: 'Aravalli Hill'** is any landform in designated districts with **100-meter elevation** and a **'Range'** are two or more hills within **500-meter proximity.**
    - SC directed Government to prepare a **Management Plan for Sustainable Mining** on the lines of the **Saranda Mining Plan**. (see box)
- **Government Bans Mining (December 2025): MoEF&CC** issued **directions** to **States** for a **complete ban** on granting **new mining leases** (exception for critical, strategic and atomic minerals).

Saranda Forest case (2025) and Mining Plan

- SC ordered **Jharkhand** to declare **Saranda Forest a wildlife sanctuary.**
- Noting that a **ban** on mining could promote **illegal mining**, it ordered a **Mining Plan** based on **geo-referenced ecological assessments** to divide the landscape into **"Go" and "No-Go" zones for mining.**
- **Exemplifying balancing ecological** preservation with **economic growth**.

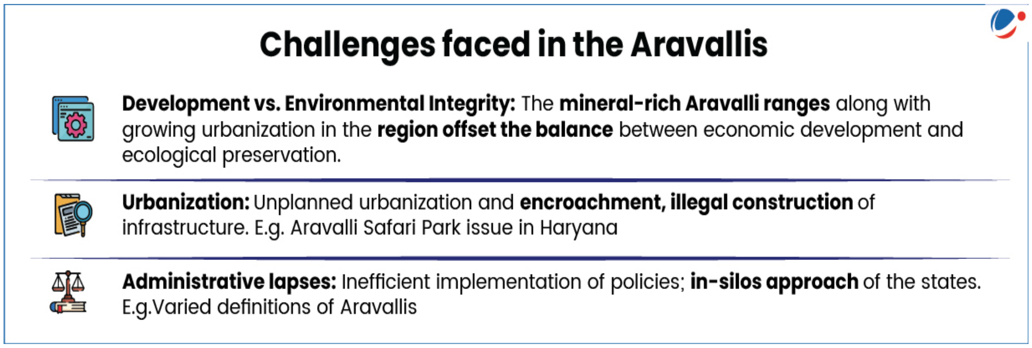
- **Judicial Stay and Review (December 2025)**: Following **public protests**, SC **stayed** its November directions proposing fresh review.
    - Public protests were due to **potential ecological destruction, threat of desertification, groundwater crisis, etc.**

About Aravallis

- **One of the oldest residual fold mountain ranges** of world **(Pre-Cambrian),** and **predates formation of the Himalayan ranges.**
- **Location**: **North-western India;** stretches in **south-west** direction **~692 km** from **Delhi through Haryana, Rajasthan, and into Gujarat.**

Significance of Aravallis

- **Acts as a barrier** against eastward expansion of Thar Desert into Indo-Gangetic Plains.
- **Rich in minerals** like **limestone, marble, sandstone. E.g. Khetri Copper mines.**
- **Deep cultural/spiritual connections** E.g. **'Mandana art' of Meenas; home to architectural wonders (Dilwara Jain Temples, etc.).**
- **Historically, Aravallis sustained human habitation** since Palaeolithic period (E.g. Mangar Bani) and developed Ahar-Banas tradition (c. 3000–1500 BCE) during Chalcolithic era.



Challenges faced in the Aravallis

- **Development vs. Environmental Integrity:** The **mineral-rich Aravalli ranges** along with growing urbanization in the **region offset the balance** between economic development and ecological preservation.
- **Urbanization:** Unplanned urbanization and **encroachment, illegal construction** of infrastructure. E.g. Aravalli Safari Park issue in Haryana
- **Administrative lapses:** Inefficient implementation of policies; **in-silos approach** of the states. E.g.Varied definitions of Aravallis

Initiatives taken to protect Aravallis

- **Matri Van Initiative:** Develop **750-acre urban forest** in **Aravalli** under **'Ek Ped Maa Ke Naam'**
- **Aravalli Green Wall Project**: Green **5 km buffer area** around **Aravalli Hill Range in four states.**
- **State Government Measures:** Haryana declared **Mangar Bani** (part of Aravalli) a **"no-construction zone"** in 2016.
- **MC Mehta v. Union of India Case (2002):** In a series of judgments, Supreme Court acknowledged the importance of Aravalli.
- **Social Movement: Save Aravalli Movement** is a grassroot environmental movement led by Rajendra Singh (Waterman of India) and resulted SC's halting of mining in Sariska Region in 1990.

Conclusion

Sustainable management of Aravalli ranges requires treating them as **continuous geological ridge** supported by **transparent data, strict enforcement of mining bans** in sensitive zones.

5.2.4. BIODIVERSITY GOVERNANCE

Why in the news?

Recently **National Biodiversity Authority (NBA)** adopted a new framework towards strengthening implementation of **Biological Diversity Act (BDA), 2002.**

New Framework

- **ABS Fund Utilisation**
    - **Identifiable Sources:**
        - When resources are sourced from identifiable institutions or repositories, 25–40% of ABS funds go to them.

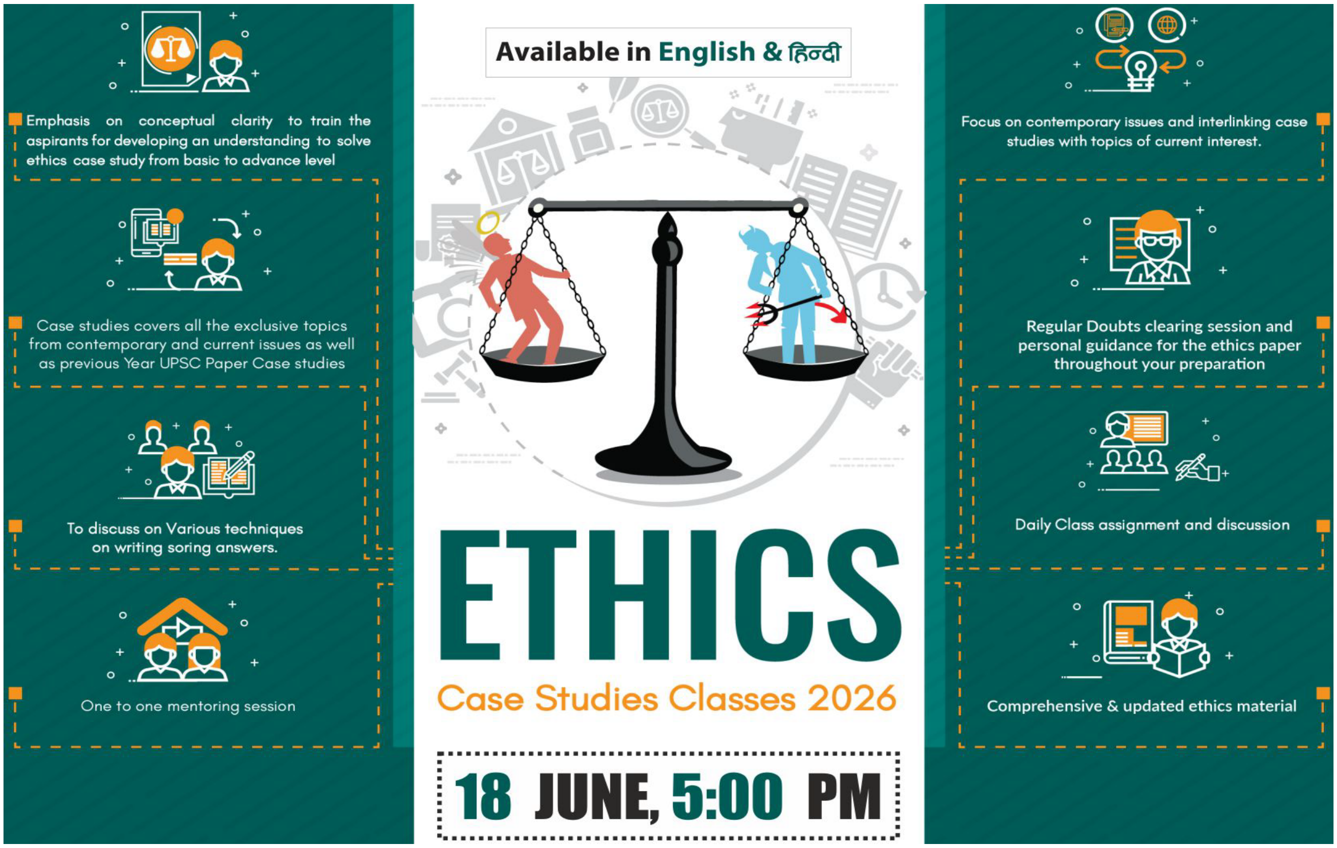
    - Remaining 60–75% is shared with local communities via **State Biodiversity Boards (SBBs) and Union Territory Biodiversity Councils (UTBCs).**
  - **Unidentifiable Origins**: If resources are accessed from intermediaries or traders, the ABS funds will be utilized directly for biodiversity conservation and management.
  - **Revised Repository Guidelines:** Includes provisions like Promotion of digital records for traceability and identification.

Biodiversity Governance Framework in India

- **The Biological Diversity Act (BDA), 2002** provides for conservation of **biological diversity**, **sustainable use** of its components and fair **Access and Benefit Sharing (ABS)** for utilization of genetic resources.
  - BDA was enacted to fulfil India's obligations under the **United Nations Convention on Biological Diversity (CBD).**
- **Three-Tier Structure:**
  - **National Biodiversity Authority (NBA):** Operates at the **national level** to regulate access to biological resources by foreign entities, the transfer of research results abroad, etc.
  - **State Biodiversity Boards (SBBs):** Regulates access to resources by Indian citizens and entities for commercial purposes.
  - **Biodiversity Management Committees (BMCs): Local self-government institutions** tasked with documenting local biodiversity and traditional knowledge in **People's Biodiversity Registers (PBRs)**.
- **Grassroot Biodiversity Governance Initiatives: 'Strengthening Institutional Capacities for Securing Biodiversity Conservation Commitments'** project has been launched by the **Ministry of Environment, Forest and Climate Change** and **National Biodiversity Authority** (NBA) in Tamil Nadu and Meghalaya.

Conclusion

India's biodiversity **governance architecture** together with its institutions and processes strengthen **ecological resilience, local stewardship and alignment with global biodiversity goals** under Convention on Biological Diversity (CBD).



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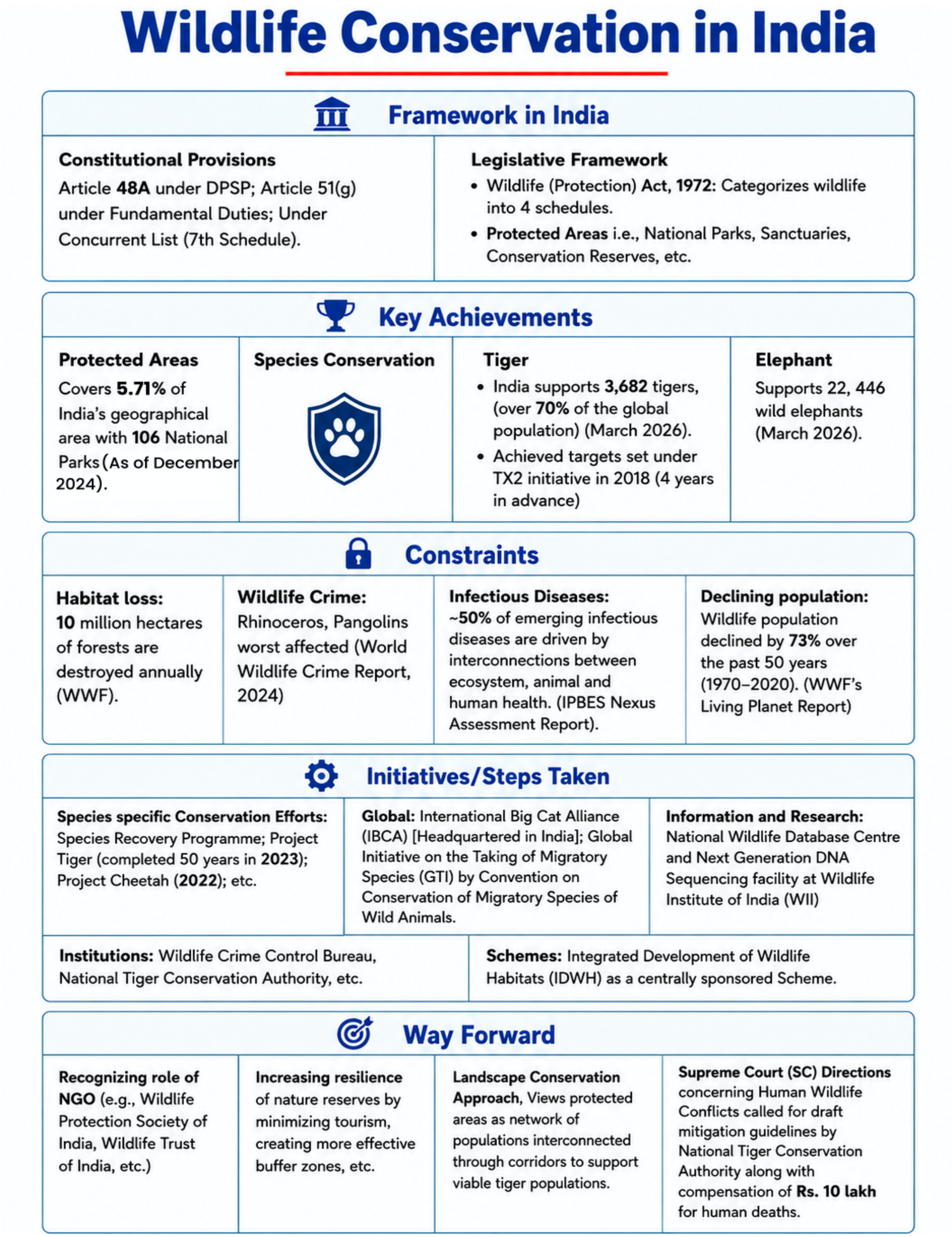
5.2.5. WILDLIFE CONSERVATION IN INDIA AT A GLANCE



Wildlife Conservation in India

Framework in India

Constitutional Provisions
Article **48A** under DPSP; Article 51(g) under Fundamental Duties; Under Concurrent List (7th Schedule).

Legislative Framework
- Wildlife (Protection) **Act, 1972:** Categorizes wildlife into 4 schedules.
- **Protected Areas** i.e., National Parks, Sanctuaries, Conservation Reserves, etc.

Key Achievements

Protected Areas
Covers **5.71%** of India's geographical area with **106** National Parks (As of December 2024).

Species Conservation

Tiger
- India supports **3,682** tigers, (over **70%** of the global population) (March 2026).
- Achieved targets set under TX2 initiative in 2018 (4 years in advance)

Elephant
Supports 22, 446 wild elephants (March 2026).

Constraints

Habitat loss: **10** million hectares of forests are destroyed annually (WWF).

Wildlife Crime: Rhinoceros, Pangolins worst affected (World Wildlife Crime Report, 2024)

Infectious Diseases: ~**50%** of emerging infectious diseases are driven by interconnections between ecosystem, animal and human health. (IPBES Nexus Assessment Report).

Declining population: Wildlife population declined by **73%** over the past 50 years (1970–2020). (WWF's Living Planet Report)

Initiatives/Steps Taken

Species specific Conservation Efforts: Species Recovery Programme; Project Tiger (completed 50 years in **2023**); Project Cheetah (**2022**); etc.

Global: International Big Cat Alliance (IBCA) [Headquartered in India]; Global Initiative on the Taking of Migratory Species (GTI) by Convention on Conservation of Migratory Species of Wild Animals.

Information and Research: National Wildlife Database Centre and Next Generation DNA Sequencing facility at Wildlife Institute of India (WII)

Institutions: Wildlife Crime Control Bureau, National Tiger Conservation Authority, etc.

Schemes: Integrated Development of Wildlife Habitats (IDWH) as a centrally sponsored Scheme.

Way Forward

Recognizing role of NGO (e.g., Wildlife Protection Society of India, Wildlife Trust of India, etc.)

Increasing resilience of nature reserves by minimizing tourism, creating more effective buffer zones, etc.

Landscape Conservation Approach, Views protected areas as network of populations interconnected through corridors to support viable tiger populations.

Supreme Court (SC) Directions concerning Human Wildlife Conflicts called for draft mitigation guidelines by National Tiger Conservation Authority along with compensation of **Rs. 10 lakh** for human deaths.

5.2.6. HUMAN WILDLIFE CONFLICT

Why in the news?

Recently increasing instances of Human-Elephant conflicts were witnessed in Jharkhand and West Bengal.

About Human Wildlife Conflict

- **Status in India:** 1630 people killed by animals (Accidental Deaths & Suicides in India 2024)
- **Primary responsibility for management:** Respective State/ UT Government.
    - Kerala declared Human Wildlife Conflict as a state-specific disaster.
- **Impacts:** Rising zoonotic diseases like Nipah; Damage to crops; Retaliatory killing; Predation of livestock; antipathy towards animals impacting conservation efforts etc.

Triggers for Human–Wildlife Conflict

- **Man-Made Triggers**
    - **Habitat Loss and Fragmentation:** Deforestation, expansion of agriculture, human settlements etc. pushes animals into human settlements.
    - **Infrastructure Development:** Construction of highways, railway tracks block traditional migratory corridors.
- **Natural Triggers**
    - **Climate Variability:** Like droughts, rising temperatures reduce food and water availability.
    - **Seasonal Migration Patterns**: Animals migrate in search of forage and water.
    - **Natural Habitat Degradation**: Wildfires, invasive species spread, or ecological changes reduces forage.

Laws and Policy to tackle HAC

- Forest and wildlife are listed in **the Concurrent List of the Constitution.**
- **Wildlife Protection Act of 1972** provides the statutory framework for protecting wild animals and plants.
- **Standard Operating Procedures (SOPs):** Issued by Central government to manage Human-Tiger/Human-Leopard /Human-Elephant conflicts.
- **Others:** National Wildlife Action Plan 2017-2035 (NWAP); National Human-Wildlife Conflict Mitigation Strategy and Action Plan (2021-26); Elephant Corridors etc.

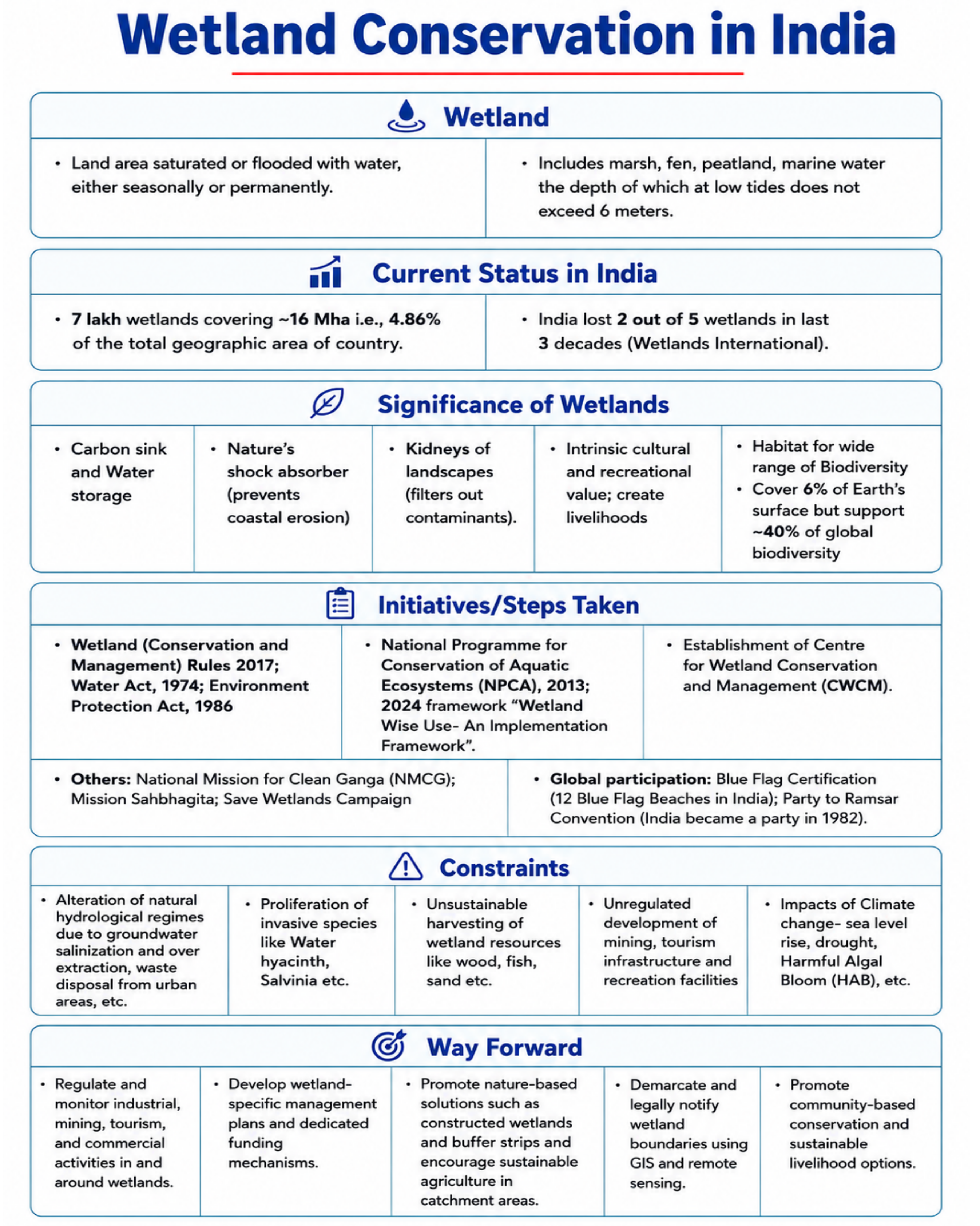
Way forward

- **National wildlife Action Plan (2017-2035)**
    - **Science-based plans** for species-specific and region-specific conflict-mitigation programs.
    - **Participation of local community** involving dissemination of Indigenous Traditional Knowledge.
- **Other measures:**
    - **Secure and legally protect wildlife corridors** to reconnect fragmented habitats through initiatives like IFAW's Room to Roam.
    - **Early Warning/Technology** like SMS alerts, LED warning systems, sensors, GPS collars, etc.
    - **Install Physical and Biological Barriers** like solar fencing, trenches, bee-hive fences, chilli deterrents, and bio-fencing.
    - **Habitat Improvement Measures** like developing waterholes, borewells, fodder plantations, and removing invasive species.
    - **Alternative Cropping Patterns**, e.g., cultivation of elephant-unpalatable crops like chilli, citrus, ginger, and onion in vulnerable areas.

Conclusion

Understanding human-wildlife conflict is an important first step in the **conservation of highly endangered species** complemented by **variety of management strategies** being deployed at local level.

5.3. WETLAND CONSERVATION IN INDIA AT A GLANCE



Wetland Conservation in India

Wetland

- Land area saturated or flooded with water, either seasonally or permanently.
- Includes marsh, fen, peatland, marine water the depth of which at low tides does not exceed 6 meters.

Current Status in India

- **7 lakh** wetlands covering ~**16 Mha** i.e., **4.86%** of the total geographic area of country.
- India lost **2 out of 5** wetlands in last 3 decades (Wetlands International).

Significance of Wetlands

- Carbon sink and Water storage
- Nature's shock absorber (prevents coastal erosion)
- Kidneys of landscapes (filters out contaminants).
- Intrinsic cultural and recreational value; create livelihoods
- Habitat for wide range of Biodiversity
- Cover **6%** of Earth's surface but support ~**40%** of global biodiversity

Initiatives/Steps Taken

- **Wetland (Conservation and Management) Rules 2017; Water Act, 1974; Environment Protection Act, 1986**
- National Programme for Conservation of Aquatic Ecosystems **(NPCA), 2013; 2024** framework **"Wetland** Wise Use- An Implementation Framework".
- Establishment of Centre for Wetland Conservation and Management (**CWCM**).
- **Others:** National Mission for Clean Ganga (NMCG); Mission Sahbhagita; Save Wetlands Campaign
- **Global participation:** Blue Flag Certification (12 Blue Flag Beaches in India); Party to Ramsar Convention (India became a party in 1982).

Constraints

- Alteration of natural hydrological regimes due to groundwater salinization and over extraction, waste disposal from urban areas, etc.
- Proliferation of invasive species like Water hyacinth, Salvinia etc.
- Unsustainable harvesting of wetland resources like wood, fish, sand etc.
- Unregulated development of mining, tourism infrastructure and recreation facilities
- Impacts of Climate change- sea level rise, drought, Harmful Algal Bloom (HAB), etc.

Way Forward

- Regulate and monitor industrial, mining, tourism, and commercial activities in and around wetlands.
- Develop wetland-specific management plans and dedicated funding mechanisms.
- Promote nature-based solutions such as constructed wetlands and buffer strips and encourage sustainable agriculture in catchment areas.
- Demarcate and legally notify wetland boundaries using GIS and remote sensing.
- Promote community-based conservation and sustainable livelihood options.

5.3.1. INDIA'S RESOLUTION ON WISE-USE OF WETLANDS

Why in the News?

India's resolution titled **'Promoting Sustainable Lifestyles for Wetlands'** aligned with Mission LiFE was adopted at **Ramsar 15th Conference of Parties, Zimbabwe**, with support of 172 countries.

Other Outcomes of COP15

Outcome/Initiative	Description
"Victoria Falls" Declaration	Acknowledges ecological, social, and economic roles of wetlands.
Indo-Burma Ramsar Regional Initiative (IBRRI) Strategic Plan 2025–2030	To halt and reverse wetland loss Cambodia, Lao PDR, Myanmar, Thailand, Vietnam
Launch of BRIDGE Programme	Grants on gender mainstreaming and women leadership
Freshwater Challenge	To enhance implementation of the Convention
Endorsement of establishment of Global Waterbird Estimates Partnership (GWEP)	GWEP (established under Ramsar Convention) integrates data sources, build monitoring capacity, provide information for conservation agreements to combat the global decline of waterbird populations and wetland degradation.

About Ramsar Convention

- Adopted in **1971, Iran, enforced in 1975.**
- **Intergovernmental treaty** for conservation and wise use of wetlands.
- **India's participation:**
    - **100 Ramsar sites**: E.g. of most recent additions- Jai Prakash Narain Bird Sanctuary, Uttar Pradesh; Shekha Jheel Bird Sanctuary; Uttar Pradesh; Chhari-Dhand Wetland Reserve, Gujarat; Patna Bird Sanctuary, Uttar Pradesh.
    - 2 cities in **global list of accredited wetland cities (Indore** and **Udaipur)**
- **Significance of the Ramsar Convention**
    - Fulfilling Sustainable Development Goals.
    - Promoting Research and Data Exchange among parties.
    - Fostering International Cooperation.
    - Recognising Intricate Relationship between Humans and Environment.

About Wise Use of Wetland

- Core principle of wetland conservation under **Ramsar Convention**.
    - Convention defines wise use as **maintaining ecological character** of wetlands using **ecosystem-based approaches** within sustainable development.
- Contracting parties are mandated to promote wise use through **national plans, legislation, management actions and public education.**

Implications of unwise use

- **Loss of wetlands:** E.g., **74% of total lakes** in Jammu and Kashmir have either completely vanished or significantly shrunk since 1967. (CAG report)
- **Loss of biodiversity:** E.g., **disappearance of native fish** like **Schizothorax richardsonii** and **Bangana diplostoma** from Wular Lake.
- **Livelihoods Threats**: Degradation and pollution threaten **fishing communities**, those dependent on aquatic plants like lotus stems and water chestnuts, and **tourism** (houseboat operators).
- **Public Health**: Accumulation of **toxic heavy metals** (copper, lead, etc.) in fish causes brain, liver, and kidney damage to consumers.

Conclusion

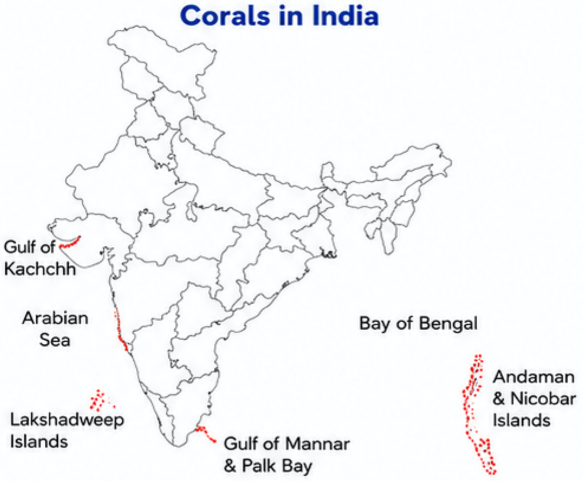
Protecting wetlands through **scientific management, strong governance, and community stewardship** is crucial for ensuring ecological security and sustainable development.

5.3.2. CORAL BLEACHING AT A GLANCE

Coral Bleaching

- **Corals:** Organisms in symbiotic relationship with microscopic algae (zooxanthellae), acting as primary food source.
- **Coral Bleaching:** Occurs when corals are stressed by changes in conditions like temperature, light, or nutrients.
  - They expel zooxanthellae living in their tissues, causing them to turn completely white.
- **Ideal Conditions for Survival:**
  - **Clean Water** (Essential for Coral Health);
  - **Warm Water** (between 23° and 29° Celsius);
  - **Healthy Wildlife Populations** (Herbivores like parrotfish are vital for grazing on algae).

Corals in India



Significance of Coral Reefs

Biodiversity Hotspots
Support approximately **25%** of all marine species

Coastal Protection
Natural breakwaters protecting coastlines from storms, erosion, etc.

Economic Value
~$10 trillion in economic benefits globally through tourism, fisheries etc.

Threat to Coral Reefs

Bleaching

- **4th mass** coral bleaching event announced by the NOAA in 2024.
- **Ningaloo Reef** (World Heritage Site), on Australia's West Coast suffered major bleaching in recent years.
- **Great Barrier Reef** (world's largest coral system) experienced biggest decline in four decades.

Other Threats: Climate Warming; Coral Mining for construction; Aquarium Trade; overfishing; Ocean Acidification; Pollution, etc.

Initiatives/Steps Taken

India

- Coral Species listed under Schedule I of Indian Wildlife (Protection) Act, 1972.
- National Committee on Wetlands, Mangroves and Coral Reefs (1986).
- Environment (Protection) Act, 1986: Prohibits coral and sand use for construction.

Global

- International Coral Reef Initiative (**ICRI**): India is a member
- World Heritage Convention designates coral reef sites for protection.
- CITES to regulate trade.
- Philippines' coral larvae cryobank to preserve reef biodiversity.

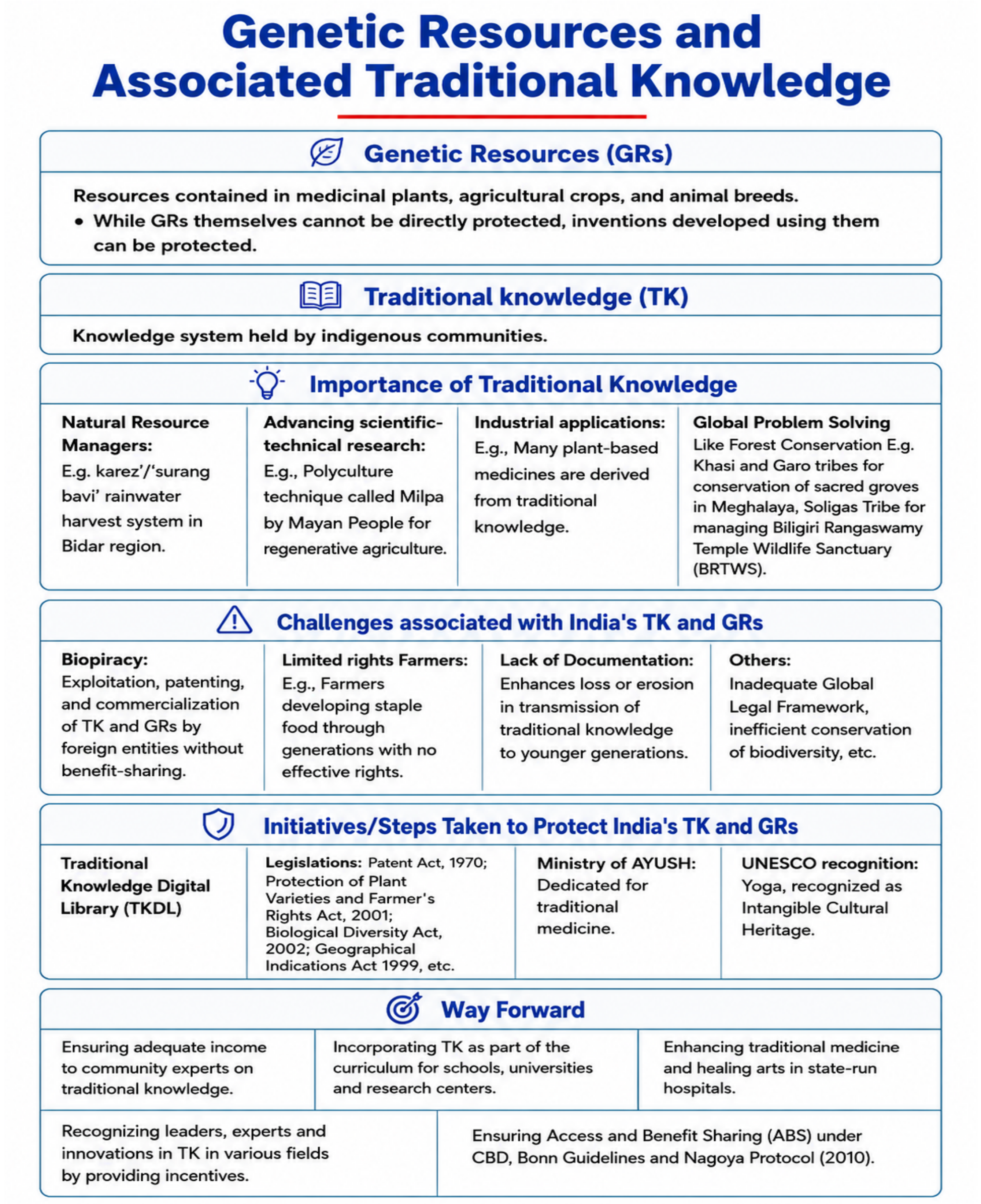
Way Forward

Reduce stormwater runoff to prevent water pollution and combat climate change.

Cryopreservation
E.g., Taronga Cry Diversity Bank

Engineering Tools
Biorock Technology (Gulf of Kutch)
Artificial Reefs (Tamil Nadu)

5.4. GENETIC RESOURCES AND TRADITIONAL KNOWLEDGE AT A GLANCE



Genetic Resources and Associated Traditional Knowledge

Genetic Resources (GRs)

Resources contained in medicinal plants, agricultural crops, and animal breeds.

- While GRs themselves cannot be directly protected, inventions developed using them can be protected.

Traditional knowledge (TK)

Knowledge system held by indigenous communities.

Importance of Traditional Knowledge

Natural Resource Managers: E.g. karez'/'surang bavi' rainwater harvest system in Bidar region.

Advancing scientific-technical research: E.g., Polyculture technique called Milpa by Mayan People for regenerative agriculture.

Industrial applications: E.g., Many plant-based medicines are derived from traditional knowledge.

Global Problem Solving Like Forest Conservation E.g. Khasi and Garo tribes for conservation of sacred groves in Meghalaya, Soligas Tribe for managing Biligiri Rangaswamy Temple Wildlife Sanctuary (BRTWS).

Challenges associated with India's TK and GRs

Biopiracy: Exploitation, patenting, and commercialization of TK and GRs by foreign entities without benefit-sharing.

Limited rights Farmers: E.g., Farmers developing staple food through generations with no effective rights.

Lack of Documentation: Enhances loss or erosion in transmission of traditional knowledge to younger generations.

Others: Inadequate Global Legal Framework, inefficient conservation of biodiversity, etc.

Initiatives/Steps Taken to Protect India's TK and GRs

Traditional Knowledge Digital Library (TKDL)

Legislations: Patent Act, 1970; Protection of Plant Varieties and Farmer's Rights Act, 2001; Biological Diversity Act, 2002; Geographical Indications Act 1999, etc.

Ministry of AYUSH: Dedicated for traditional medicine.

UNESCO recognition: Yoga, recognized as Intangible Cultural Heritage.

Way Forward

- Ensuring adequate income to community experts on traditional knowledge.
- Incorporating TK as part of the curriculum for schools, universities and research centers.
- Enhancing traditional medicine and healing arts in state-run hospitals.
- Recognizing leaders, experts and innovations in TK in various fields by providing incentives.
- Ensuring Access and Benefit Sharing (ABS) under CBD, Bonn Guidelines and Nagoya Protocol (2010).

5.4.1. INTERNATIONAL TREATY ON PLANT GENETIC RESOURCES FOR FOOD AND AGRICULTURE (ITPGRFA)

Why in the News?

11th session of Governing Body of **ITPGRFA** concluded in Lima, Peru with a recent **UN Special Rapporteur** cautioning on Digital Sequence Information (DSI) as main issues in the treaty.

Key Highlights of the Session

- Talks on **Multilateral System (MLS) for functioning of access and benefit sharing** failed.
  - MLS governs the **sharing of genetic resources from 35 major food crops and 29 forages.**
  - These together make up about **80 per cent of the world's plant-based diet** and are described in **Annexure 1 of the Treaty.**
  - On adopting ITPGRFA, country agrees to make **genetic diversity of these crops, particularly from public gene banks,** available to all other members through the MLS.
- **Compromise proposal at 11th session of the Governing Body (GB 11)**
  - Adopting the revised standard material transfer agreement (SMTA).
    - SMTA regulates **exchanges of plant genetic material,** prevents their misuse, and ensuring fairly and equitably sharing of benefits.
  - Key issues like **payment system, Annex I expansion, and Digital Sequence Information** rules postponed to the next meeting (GB12).
- **India's Stand:** Safeguard sovereign rights and fair benefit-sharing, opposing opaque draft and calling for all unresolved issues to be revisited at GB12.

About ITPGRFA

- **First Legally binding Treaty on Crop Genetic Diversity** to Conserve Crop Diversity; Sustainable Use of Genetic Resources and Fair and Equitable Benefit sharing.
- **Adopted at FAO Conference at 2001**. Enforced in **2004.**
- **India is a Member.**

Digital Sequence Information (DSI)

- It is a placeholder term in the discussions under **1992 Conventions on Biological Diversity.**
  - However, there is **no consensus** on its exact definition under CBD.
- Generally, **DSI refers to digital storage of genetic data** derived from DNA, RNA, proteins or other biological sequences.
  - It is a tool for **scientific research used by public and private sectors**, supporting sustainable development.
- **Cali Fund for DSI:** Global benefit-sharing mechanism created at **CBD COP-16** to ensure that profits from the use of **DSI** are shared fairly.

Significance of DSI

- **Nutritional Security:** Faster, more targeted development of climate-resilient and disease-resistant crop varieties.
- **Preservation of Agrobiodiversity:** Complements physical gene banks with digital repositories.
- **Global Scientific Cooperation:** Democratises breeding research and enhances innovation in developing countries.

Challenges in DSI Governance

- **Unclear Definition:** No global consensus on what constitutes DSI, creating ambiguity.
- **Digital Biopiracy:** DSI can be exploited without consent or disclosure.
- **Weaken Farmers' Control:** DSI risks marginalising farmers and indigenous communities who are traditional custodians of genetic knowledge.

Conclusion

Despite ambiguity, DSI serves as a **critical tool for conservation and sustainable use of genetic resources** with countries relying on it to deal with issues like **human, animal and plant health, food security and environment.**

5.5. KEYWORDS

Biological Diversity	Kunming-Montreal Global Biodiversity Framework	High Seas Treaty	Compensatory Afforestation	Genetic Diversity
Biodiversity Governance	Landscape-Based Conservation	Nature-Based Solutions	Wise Use of Wetlands	Genetic Resources
Traditional Knowledge	Digital Sequence Information	Cali Fund	Community-Based Conservation	Access and Benefits Sharing
30 by 30 target	Bonn Challenge	Human Wildlife Conflict	Habitat Loss	Mass coral bleaching event

5.6. PRACTICE QUESTION

<table>
<tr><td colspan="4">Aravalli, despite holding great ecological and cultural significance, is subjected to grave degradation. In this regard, highlight the key benefits of the Aravalli. Also, mention the key developmental challenges obstructing its conservation along with measures taken to restore the landscape.</td></tr>
<tr><td>Introduction</td><td>Body Part 1</td><td>Body Part 2</td><td>Conclusion</td></tr>
<tr><td>Mention about Aravalli briefly- nature and extent.</td><td>Mention the significance of the Aravalli- ecological and cultural both.</td><td>Highlight the challenges and briefly mention the initiatives taken towards its conservation.</td><td>Provide a way forward in the form of necessary regulation on issues like mining.</td></tr>
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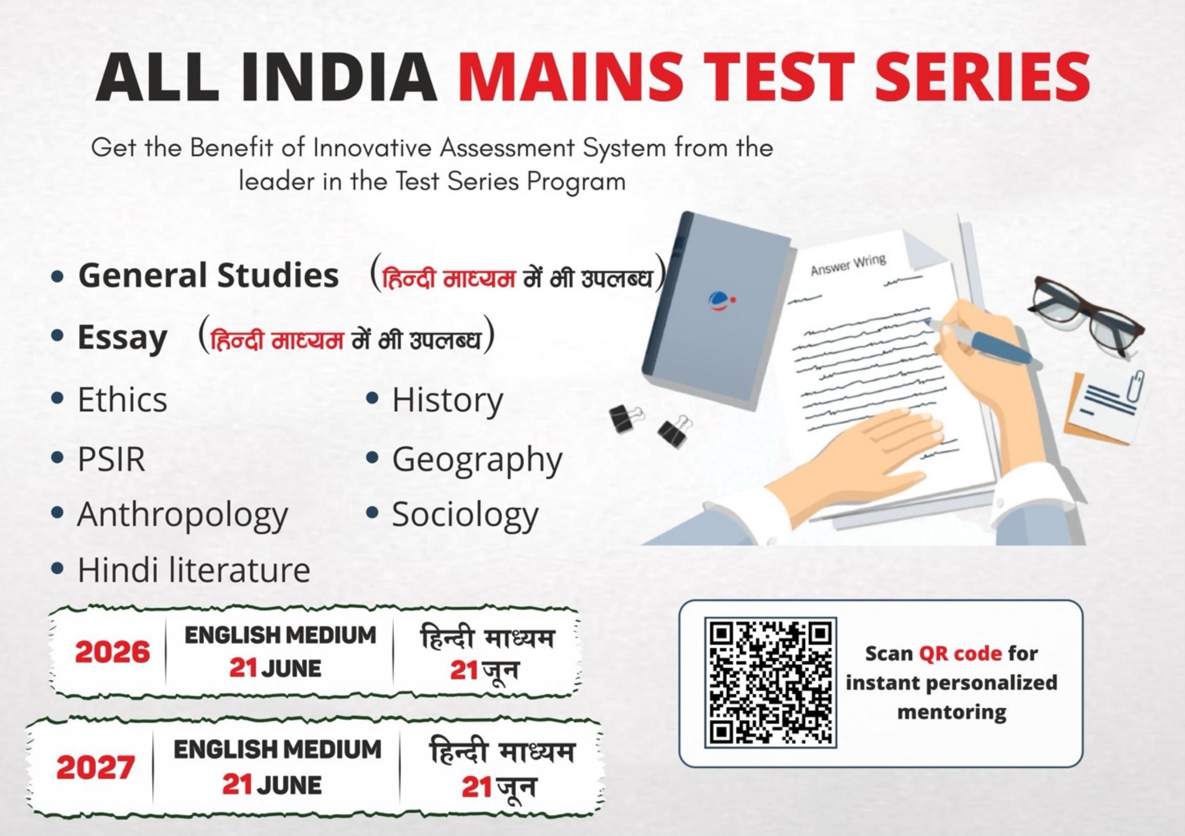
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6. DISASTER MANAGEMENT

6.1. DISASTER RISK REDUCTION (DRR) FINANCING

Why in the News?

India showcased the **World's Largest Disaster Risk Reduction Financing System** at the 8th session of the **Global Platform for Disaster Risk Reduction (GP2025).**

What is Disaster Risk Reduction (DRR)?

- It refers to the steps taken to prevent new and reduce existing **disaster risk** and **manage risk retention (aka residual risk)**, thereby strengthening resilience and sustainable development.
    - E.g., New hazard-resilient infrastructure.

Existing Financing Mechanism of DRR

United Nations and Multilateral Funds	Multilateral Development Banks (MDBs)	National-Level	Bilateral Aid and Partnerships	Other
● E.g. **Green Climate Fund (GCF)** supports DRR	● **E.g. World Bank's** Disaster Risk Financing and Insurance (DRFI) Program	● Including DRR into national and local budgets. ● **Climate Finance** (e.g. National Adaptation Plans (NAPs)), etc.	● E.g., USAID supports various DRR programs	● Private Sector and **Blended Finance** (e.g., Corporate social responsibility)

India's Disaster Risk Reduction (DRR) Financing System

- **Four key principles India's DRR financing approach**
    - **Dedicated financial windows** for **preparedness**, **mitigation**, **relief**, and **recovery**.
    - Prioritization of the **needs of affected people** and **vulnerable communities**.
    - Accessibility of **financial resources across all government levels**—central, state, and local.
    - **Accountability**, **transparency**, and **measurable outcomes** guide all expenditures.
- **Finance Mechanism:** Pre-determined, rule-based allocations from national to state and district levels, supported by **the Disaster Management Act of 2005**.
- **Measurement Tool: Disaster Risk Index (DRI), composite measure** that quantifies the **level of risk a region faces** from multiple hazards.
    - **Genesis: Formally adopted by 15th Finance Commission** (2021–26); integrates each state's DRI for distributing National Disaster Response Fund (NDRF) and state contingency funds.
    - **Components:** Uses probability of **hazards** (score: 70) and **vulnerability** (score: 30).
        - Hazards mainly focus on probability of disasters and Below Poverty Line (BPL) population is used as a basic measure to assess vulnerability.
- **Current Allocations** under **15th Finance Commission (FC)**: Exceeds **INR 2.32 trillion (~USD 28 billion).**

Funds for DRR Finance

- **Disaster Mitigation Funds: National Disaster Mitigation Fund (NDMF) and State Disaster Mitigation Fund (SDMF)** (created by 15th FC recommendations).
- **Response Funds:**
    - **National Disaster Response Fund (NDRF):** Fully financed by Union government, intended to supplement SDRF when a calamity is officially classified as "severe".

- **State Disaster Response Fund (SDRF):** Jointly financed by Centre and States, typically in a 75:25 ratio, though it is 90:10 for Himalayan and north-eastern States.

Need for financing DRR (GAR 2025)

- **Limited aid**: Just 2% of development aid goes to DRR.
- **Burden of Disasters:** Financial losses from disasters doubled in past two decades.
- **Vulnerability of Developing Countries**: Only 49% of Least developed Countries (LDCs) had multi-hazard early warning systems (2023).
- **Breaking 3 negative spirals: Decreasing Income, Increasing debt** (By 2050 global incomes could decline by 19% due to climate hazards); **Unsustainable Risk Transfer** (low insurance penetration in India, with coverage below 1%); **Respond-Repeat** (Every $1 invested in DRR saves 15$ in averting future disaster recovery costs).

Key Challenges related to DRR Financing

- **One-size-fits-all approach:** DRI fails to capture **unique vulnerabilities** of hilly/coastal regions.
- **Resource Allocation:** Because of low DRI, some states do not get adequate resources.
- **Geographical Inequalities:** Larger states receive more funds even if they have low vulnerability.
- **Limitations of DRI:** Vulnerability component ignores housing quality, health systems infrastructure, and insurance penetration.
- **Issues in Relief and response allocation:**
    - **Outdated Relief Norms**: Compensation ceilings e.g. ₹4 lakh for each life lost have remained largely unchanged for a decade.
    - **Ambiguity in Classification:** DM Act, 2005, does not define what constitutes a 'severe' disaster, allowing discretion in deciding eligibility for NDRF aid.
    - **Procedural and Slow Aid Release**: Process relies on sequential clearances, including a State memorandum, central assessment, and high-level approval.
- **Others:** Absence of **dedicated international financial mechanism**; low integration with financial decision-making; **Considered as politically risky** due to non-immediate benefits; etc.

Way Forward

- **Innovative Financial Approaches:** E.g., blended finance; debt for resilience swaps; etc.
- **Tracking Finances:** Identify volume of investment utilized out of budgeted allocation.
- **Layered Financing:** Low-cost, high frequency events might be covered through national reserves or contingent credit lines.
- **Adaptive DRI:** Scientifically validated DRI formula incorporating hazard, vulnerability, exposure, poverty-based vulnerability assessment can be replaced with a Composite Vulnerability Score etc.
    - Composite Index of NDMA, which considers unsafe buildings, social infrastructure, industries, rural-urban population, deforestation etc., will provide more accurate picture of vulnerability.
- **Global Best Practices:** E.g. Federal Emergency Management Agency (FEMA) in United States uses per capita damage thresholds; African and Caribbean insurance facilities utilize satellite data for rapid payouts etc.
- **Others:** Revising allocation based on vulnerability index; periodic review every 5 year; strengthen local data collection via remote sensing, IoT, etc.

Conclusion

DRR financing is not just a development necessity but a strategic investment for sustainable futures. To break the cycle of disaster and recovery, the global community must shift from reactive spending to proactive risk management, ensuring **resilience is at the heart of financial and policy decisions**.

6.2. LOCALIZATION OF DISASTER RISK REDUCTION (DRR)

Why in the News?

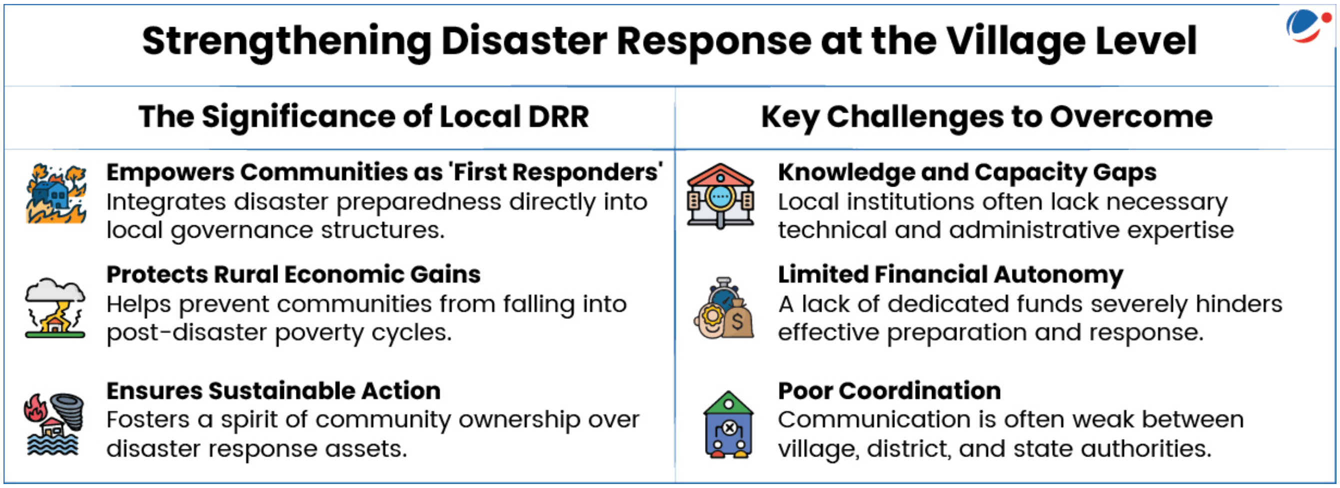
National Project for Strengthening Community-Based Disaster Risk Reduction (DRR) Initiatives in Panchayati Raj Institutions (PRIs) has been approved with an outlay of **₹507.37 crores**.

About Community-based Disaster Risk Reduction (CBDRR)

- **CBDRR** is the active **engagement of the community** in identification, analysis, assessment, monitoring, implementation and evaluation of **disaster risks** to reduce their vulnerabilities and enhance capacities.
- **Benefits: Participatory Risk Assessment** and Planning, effective **information dissemination, local knowledge and contextual understanding**, communities are 1st responders to disasters.
- **Sendai Framework for Disaster Risk Reduction (2015-30)** calls for **CBDRR.**

About the National Project for Strengthening Community-Based DRR

- **Aim**: To **integrate DRR into local governance** through a **bottom-up approach**, positioning PRIs as the backbone of disaster preparedness, mitigation and resilience at grassroots level.
- **Joint Implementation**: By **Ministry of Panchayati Raj (MoPR)** and **National Disaster Management Authority (NDMA)**.
- **Coverage:** 20 States across India, covering **81 disaster-prone districts**.
    - **Cluster-Based Model: 20** Gram Panchayats (GPs) in **each district** will be covered.
    - **Model Gram Panchayats: 20 GPs (one per state)** will be developed as "Model Gram Panchayats" focusing on **6 specific hazard themes** (e.g. floods, earthquakes, etc.).
        - They will serve as demonstrative templates for integrating disaster resilience into planning, infrastructure and community preparedness.



Strengthening Disaster Response at the Village Level

The Significance of Local DRR	Key Challenges to Overcome
Empowers Communities as 'First Responders' Integrates disaster preparedness directly into local governance structures.	**Knowledge and Capacity Gaps** Local institutions often lack necessary technical and administrative expertise
Protects Rural Economic Gains Helps prevent communities from falling into post-disaster poverty cycles.	**Limited Financial Autonomy** A lack of dedicated funds severely hinders effective preparation and response.
Ensures Sustainable Action Fosters a spirit of community ownership over disaster response assets.	**Poor Coordination** Communication is often weak between village, district, and state authorities.

Key Initiatives for Local-Level Disaster Management

- **Aapda Mitra Scheme: Training** community volunteers in disaster response.
- **Digitization:** E.g., **eGramSwaraj, Gram Manchitra, SACHET**: **Common Alerting Protocol (CAP)**, etc.
- **Local Best Practices: Ecosystem-based DRR** undertook during restoration of Tampara Wetland (Odisha); Hazard risk mapping, Formation of village-level disaster response teams, Emergency Operations Center (EOC) for disaster coordination etc. done by **Pozhuthana Panchayat, Kerala during 2018 Kerala floods** etc.

Way Forward

- **Mainstreaming DRR**, by making Disaster resilience a part of all infrastructure projects.
- **Nature-based Solutions** by restoring natural ecosystems (mangroves, wetlands, forests) for **long-term rural resilience**.
- **Scaling up learnings of 20 Model GPs** to all 2.5 lakh+ Gram Panchayats in India.
- **Effective fund allocation** from **State Disaster Mitigation Funds (SDMF).**
- **Technological integration** through user friendly apps, satellite based warning alerts, etc.

Conclusion

The boost to the **National Project** is a step in the right direction to make **PRIs and local communities "Disaster Resilient."** By empowering the local governments in DRR, disaster management will no longer be just a reactive state function but a **proactive "way of life" at the grassroots level.**

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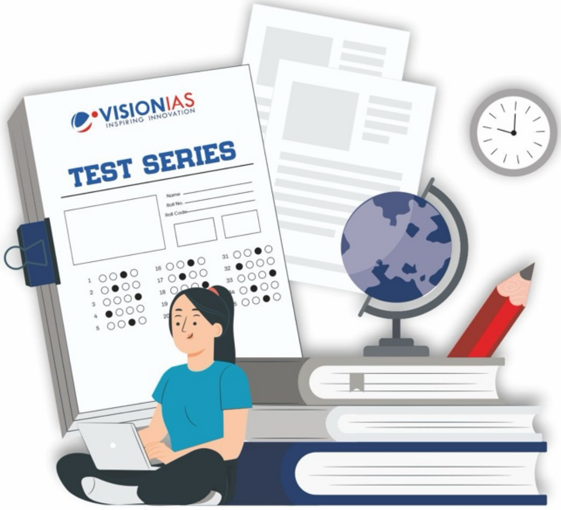

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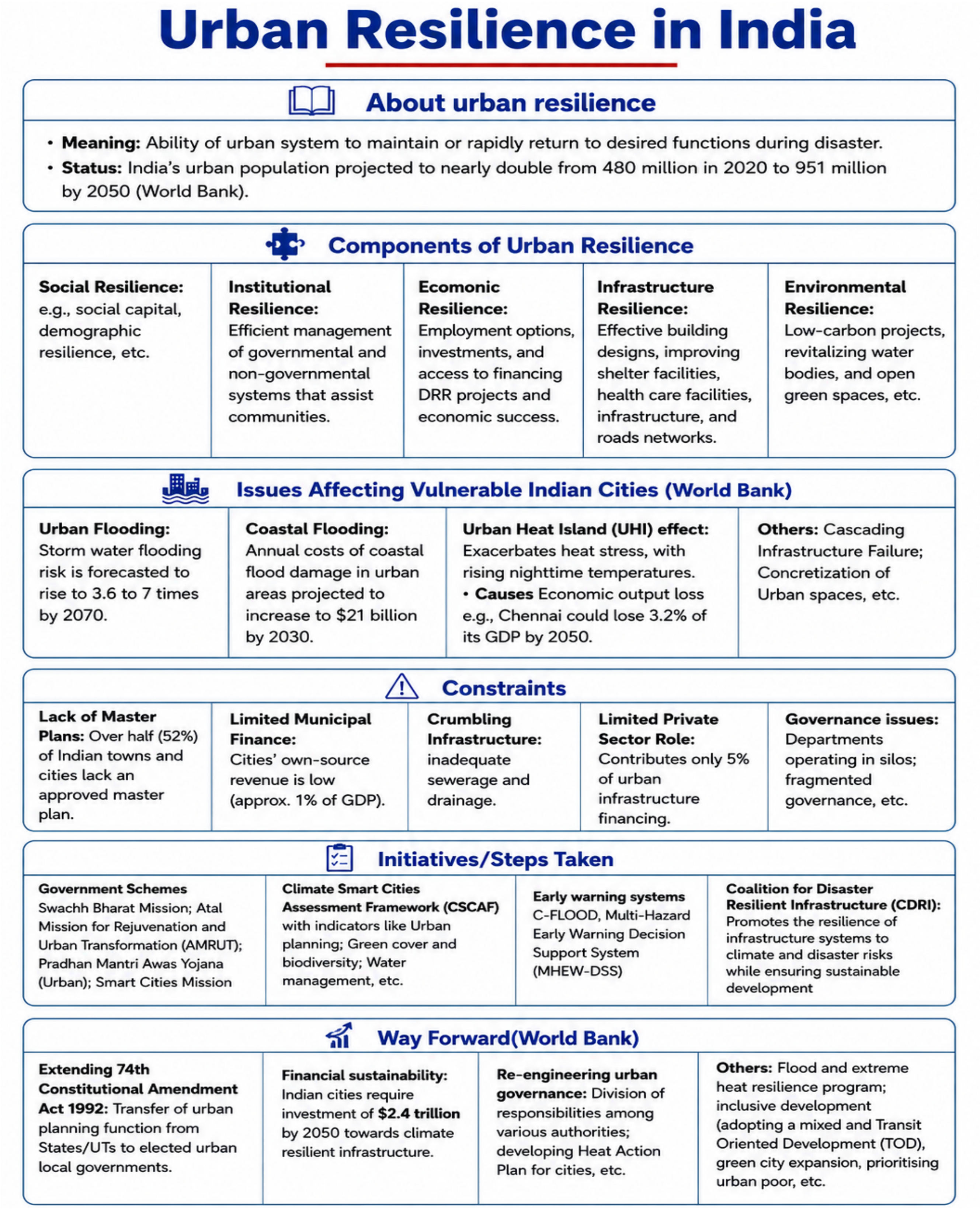
6.3. VULNERABLE REGIONS

6.3.1. URBAN RESILIENCE IN INDIA AT A GLANCE



Urban Resilience in India

About urban resilience

- **Meaning:** Ability of urban system to maintain or rapidly return to desired functions during disaster.
- **Status:** India's urban population projected to nearly double from 480 million in 2020 to 951 million by 2050 (World Bank).

Components of Urban Resilience

- **Social Resilience:** e.g., social capital, demographic resilience, etc.
- **Institutional Resilience:** Efficient management of governmental and non-governmental systems that assist communities.
- **Ecomonic Resilience:** Employment options, investments, and access to financing DRR projects and economic success.
- **Infrastructure Resilience:** Effective building designs, improving shelter facilities, health care facilities, infrastructure, and roads networks.
- **Environmental Resilience:** Low-carbon projects, revitalizing water bodies, and open green spaces, etc.

Issues Affecting Vulnerable Indian Cities (World Bank)

- **Urban Flooding:** Storm water flooding risk is forecasted to rise to 3.6 to 7 times by 2070.
- **Coastal Flooding:** Annual costs of coastal flood damage in urban areas projected to increase to $21 billion by 2030.
- **Urban Heat Island (UHI) effect:** Exacerbates heat stress, with rising nighttime temperatures.
  - **Causes** Economic output loss e.g., Chennai could lose 3.2% of its GDP by 2050.
- **Others:** Cascading Infrastructure Failure; Concretization of Urban spaces, etc.

Constraints

- **Lack of Master Plans:** Over half (52%) of Indian towns and cities lack an approved master plan.
- **Limited Municipal Finance:** Cities' own-source revenue is low (approx. 1% of GDP).
- **Crumbling Infrastructure:** inadequate sewerage and drainage.
- **Limited Private Sector Role:** Contributes only 5% of urban infrastructure financing.
- **Governance issues:** Departments operating in silos; fragmented governance, etc.

Initiatives/Steps Taken

- **Government Schemes** Swachh Bharat Mission; Atal Mission for Rejuvenation and Urban Transformation (AMRUT); Pradhan Mantri Awas Yojana (Urban); Smart Cities Mission
- **Climate Smart Cities Assessment Framework (CSCAF)** with indicators like Urban planning; Green cover and biodiversity; Water management, etc.
- **Early warning systems** C-FLOOD, Multi-Hazard Early Warning Decision Support System (MHEW-DSS)
- **Coalition for Disaster Resilient Infrastructure (CDRI):** Promotes the resilience of infrastructure systems to climate and disaster risks while ensuring sustainable development

Way Forward(World Bank)

- **Extending 74th Constitutional Amendment Act 1992:** Transfer of urban planning function from States/UTs to elected urban local governments.
- **Financial sustainability:** Indian cities require investment of **$2.4 trillion** by 2050 towards climate resilient infrastructure.
- **Re-engineering urban governance:** Division of responsibilities among various authorities; developing Heat Action Plan for cities, etc.
- **Others:** Flood and extreme heat resilience program; inclusive development (adopting a mixed and Transit Oriented Development (TOD), green city expansion, prioritising urban poor, etc.

6.3.2. COASTAL REGIONS

Why in the News?

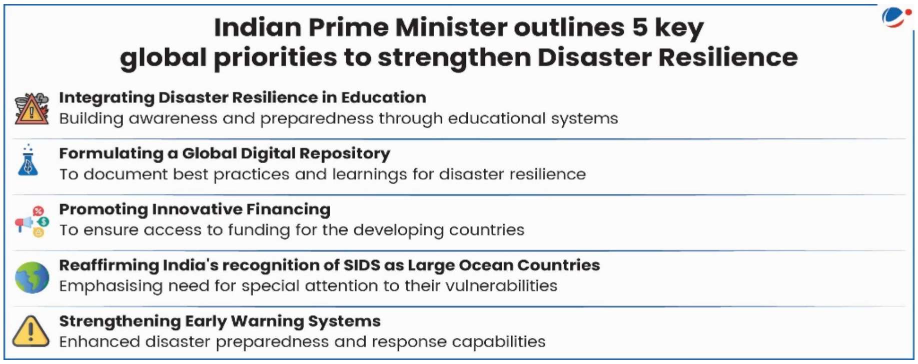
7th **International Conference on Disaster Resilient Infrastructure (ICDRI)** in France was held with the theme **‘Shaping a Resilient Future for Coastal Regions’.**

Vulnerability of Coastal Regions

- Nearly **250 million people** live within 50 km from Indian coastline.
- **Climate change causing increasing intensity and frequency of hazards** like sea level rise, floods, etc.
- **Economic losses**, e.g., Cyclone Fani caused ~**US$1.2 billion power infrastructure damages** in Odisha (2019). (Global Assessment Report (GAR), 2025)
- **Threat to Ecosystems and biodiversity,** e.g., Half of world’s mangroves could face severe risks by 2100 due to increased cyclone frequency and sea level rise **(**Risk index for mangroves).
- **Severe coastal hazards: Tsunamis** (2004 Indian Ocean Tsunami); **Cyclones** (**Cyclone Remal** struck India and Bangladesh in 2024), **Coastal Erosion** (threatening 33.6% of Indian coastline).

Indian Initiatives for Mitigating Coastal Vulnerabilities

- **Coastal Regulation Zone (CRZ) Notification (2019)** to conserve and protect coastal stretches, marine areas.
- **Integrated Coastal Zone Management Project (ICZMP)** in states like Odisha and West Bengal.
- **Coastal Vulnerability Index (CVI) and Multi-Hazard Vulnerability Maps,** developed by **Indian National Centre for Ocean Information Services (INCOIS)**
- **Coastal Management Information System (CMIS)**
- **PM’s global priorities for disaster resilience** (see infographic).
- **Coalition for Disaster Resilient Infrastructure (CDRI**), launched during United Nations Climate Action Summit in 2019 by India.
    - **Initiatives under it:** Infrastructure for Resilient Island States (IRIS); Infrastructure Resilience Accelerator**.**



Indian Prime Minister outlines 5 key global priorities to strengthen Disaster Resilience

Integrating Disaster Resilience in Education
Building awareness and preparedness through educational systems

Formulating a Global Digital Repository
To document best practices and learnings for disaster resilience

Promoting Innovative Financing
To ensure access to funding for the developing countries

Reaffirming India's recognition of SIDS as Large Ocean Countries
Emphasising need for special attention to their vulnerabilities

Strengthening Early Warning Systems
Enhanced disaster preparedness and response capabilities

Way Forward

- **Nature-based Solutions** like restoring mangroves, coral reefs, sand dunes, and coastal wetlands which act as natural buffer.
- **Develop cyclone-resilient housing**, strengthen embankments, and climate-proof critical infrastructure such as ports, roads, and power systems.
- **Enhance multi-hazard early warning systems**, evacuation plans, and community-based disaster preparedness mechanisms.
- **Promote shoreline protection measures,** including beach nourishment, dune restoration, and scientific shoreline management plans.
- **Improve coastal vulnerability assessments** through GIS, remote sensing, and climate-risk mapping.

Conclusion

As **climate risks grow, global action grounded in local needs and innovation** is vital to safeguard coastal communities and ecosystems.

6.3.3. HKH/HIMALAYAN REGION

Why in the news?

Extreme climate events have highlighted the **increased disaster vulnerability of Indian Himalayan Region (IHR) and Hindu Kush Himalayan Region.**

About Hindu Kush Himalayan Region (HKH)/IHR

- **HKH region encompasses eight nations** i.e. Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan.
- **Significance:** Hydropower Capacity (882 GW potential); high Renewable energy potential (over 3.5 TW); etc.
- **Challenges: Climate Risks** due to shifting river flows, GLOFs, etc.; **Financial hurdles** due to high project costs, etc.

Reasons for higher vulnerability of the region

- **Geology:** Himalayas are young, fold mountains with ongoing tectonic activity; making them highly susceptible to earthquakes (**Seismic Zones IV and V)**, landslides.
- **Climatic impacts:** Changes in temperature and rainfall creating intense rainfall, cloudbursts, **Deglaciation** and avalanches. **(Uttarakhand 2013, 2025 floods).**
  - **70-80% of current glacier volume** in HKH region will **disappear by 2100** under a high emission scenario. (ICIMOD)
- **Anthropogenic:** Road construction, hydroelectric projects, encroachment on riverbanks influence accelerates soil erosion, slope instability (like Tehri Dam).
- **Rising tourism:** Indian Himalayan Region records about 100 million tourists every year.

Existing disaster response mechanism

- **Multi-agency Coordination:** With NDMA, NDRF, state disaster authorities, Central Water Commission, IMD as seen in recent Punjab floods.
- **Use of technology:** Drones, satellite communication, OneWeb links, Doppler radars, etc.
- **Community-based Preparedness:** NDMA's Aapda Mitra (Friends in Disaster) programme.
- **Risk Indexing:** CWC has also finalized the Criteria for Risk Indexing of Glacial Lakes.

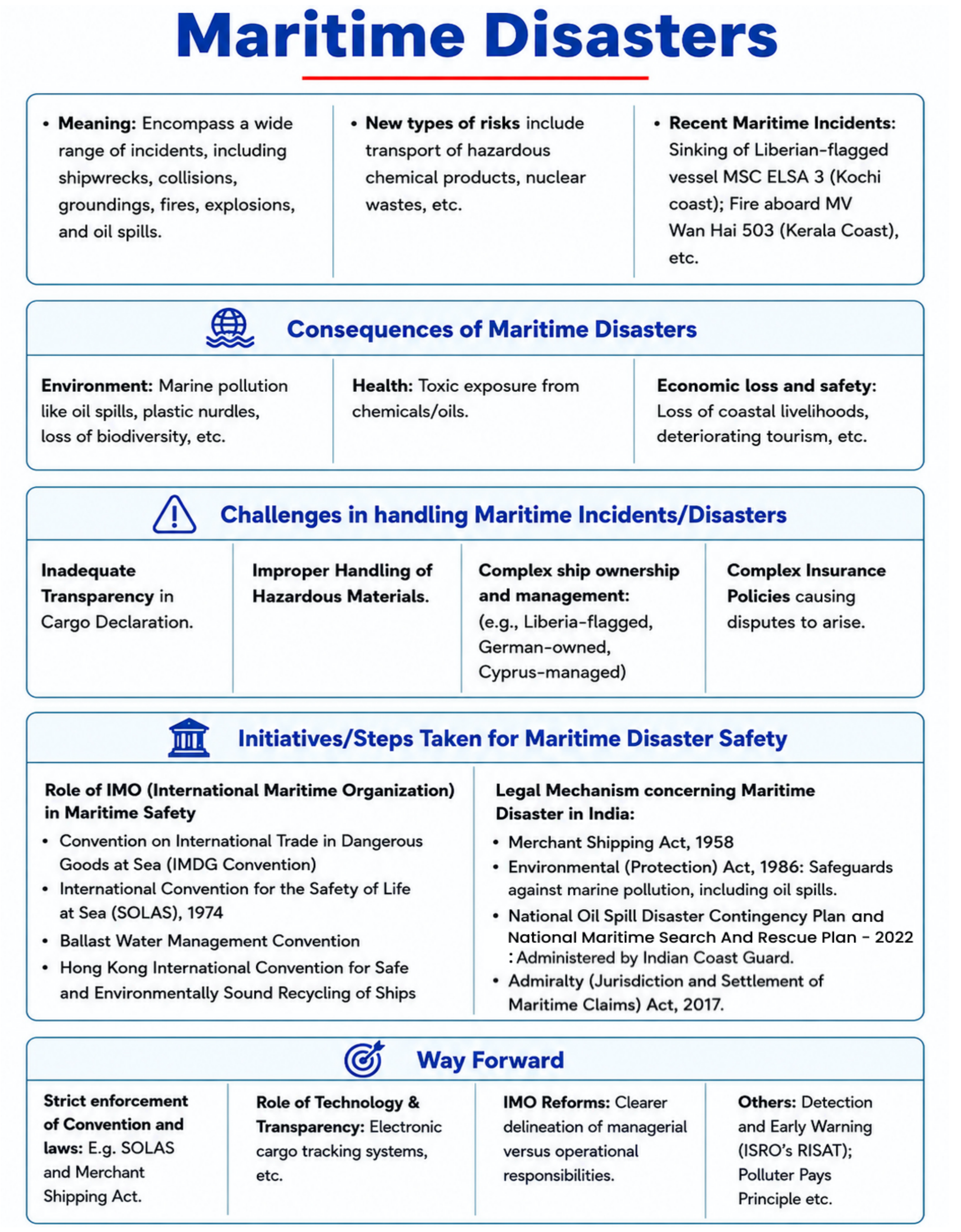
Way Forward for better preparedness

- **Monitoring:** National Remote Sensing Centre (NRSC) to monitor glacial lakes on a 24×7 basis.
- **Mapping:** Geological Survey of India (GSI) to expand landslide mapping based on soil soaking and slope gradient.
- **Technology:** Artificial intelligence, with localised hydro-met data (Gorakhpur Model of urban flood control).
- **Other:** Sachet app for early warning, slope stabilisation for roads and river embankments, etc.

Conclusion

Protecting the HKH/IHR requires **regional cooperation, more consistent and synchronised data sources,** more sharing of innovative solutions, and more global attention.

6.3.4. MARITIME DISASTERS AT A GLANCE



Maritime Disasters

- **Meaning:** Encompass a wide range of incidents, including shipwrecks, collisions, groundings, fires, explosions, and oil spills.
- **New types of risks** include transport of hazardous chemical products, nuclear wastes, etc.
- **Recent Maritime Incidents:** Sinking of Liberian-flagged vessel MSC ELSA 3 (Kochi coast); Fire aboard MV Wan Hai 503 (Kerala Coast), etc.

Consequences of Maritime Disasters

Environment: Marine pollution like oil spills, plastic nurdles, loss of biodiversity, etc.

Health: Toxic exposure from chemicals/oils.

Economic loss and safety: Loss of coastal livelihoods, deteriorating tourism, etc.

Challenges in handling Maritime Incidents/Disasters

Inadequate Transparency in Cargo Declaration.

Improper Handling of Hazardous Materials.

Complex ship ownership and management: (e.g., Liberia-flagged, German-owned, Cyprus-managed)

Complex Insurance Policies causing disputes to arise.

Initiatives/Steps Taken for Maritime Disaster Safety

Role of IMO (International Maritime Organization) in Maritime Safety

- Convention on International Trade in Dangerous Goods at Sea (IMDG Convention)
- International Convention for the Safety of Life at Sea (SOLAS), 1974
- Ballast Water Management Convention
- Hong Kong International Convention for Safe and Environmentally Sound Recycling of Ships

Legal Mechanism concerning Maritime Disaster in India:

- Merchant Shipping Act, 1958
- Environmental (Protection) Act, 1986: Safeguards against marine pollution, including oil spills.
- National Oil Spill Disaster Contingency Plan and National Maritime Search And Rescue Plan - 2022 : Administered by Indian Coast Guard.
- Admiralty (Jurisdiction and Settlement of Maritime Claims) Act, 2017.

Way Forward

Strict enforcement of Convention and laws: E.g. SOLAS and Merchant Shipping Act.

Role of Technology & Transparency: Electronic cargo tracking systems, etc.

IMO Reforms: Clearer delineation of managerial versus operational responsibilities.

Others: Detection and Early Warning (ISRO's RISAT); Polluter Pays Principle etc.

6.4. CROWD DISASTER MANAGEMENT

Why in the news?

Recently incidents of Stampede occurred at various locations including Tamil Nadu, Andhra Pradesh's Venkateswara Swamy Temple, Bengaluru (RCB's IPL celebration), etc.

About Stampede

- Stampede (**a type of crowd disaster**) or crushing is **the surge of individuals in a crowd**, in response to a **perceived danger or loss of physical space. [United Nations Office for Disaster Risk Reduction (UNDRR)].**
- **Stampedes in India**: Nearly **4,000 stampede events** were recorded in last 3 decades.
- **Human Behaviour**
    - **Breakdown of Cooperation (Mintz's Theory):** In panic situations, cooperation works only until it breaks—once disturbed, it collapses and worsens panic.
    - **Craze (Smelser's Theory):** Rush for the pursuit of something gratifying making crowds act against their own interests.
- **Lack of Enforcement**: Event venues often **exceed safe capacity limits**, **inadequate infrastructure (e.g. barricades)**, etc.
    - E.g., Chinnaswamy stadium, 2025 2.5 lakh crowd gathered as against the 34,600 capacity.
- **Lack of Stakeholder Coordination:** E.g., RCB's social media announced free entry passes at stadium gates without proper coordination with Police
- **Limited Technology Use**: E.g., **real-time surveillance systems, crowd-density analytics,** etc.
- **Other factors**: Rising pilgrimage culture due to rise in prosperity, congested urban spaces clubbed with high population density, delays in rescue, etc.

Initiatives taken to address Crowd Disasters

- **NDMA Guidelines for Managing Crowd at Events and Venues of Mass Gathering: NDMA** categorizes stampedes as **man-made disasters** and provides for capacity planning; risk and vulnerability analysis; **Failure Mode and Effect Analysis (FMEA), etc.**
- **Constitutional Provisions: Article 19(1)(b)** provides citizens right to assemble peacefully and without arms.
- **Legal Framework: Police Act 1861** provides conditions for regulating lawful processions; Disaster Management Act, 2005, etc.

Way Forward: NDMA Guidelines

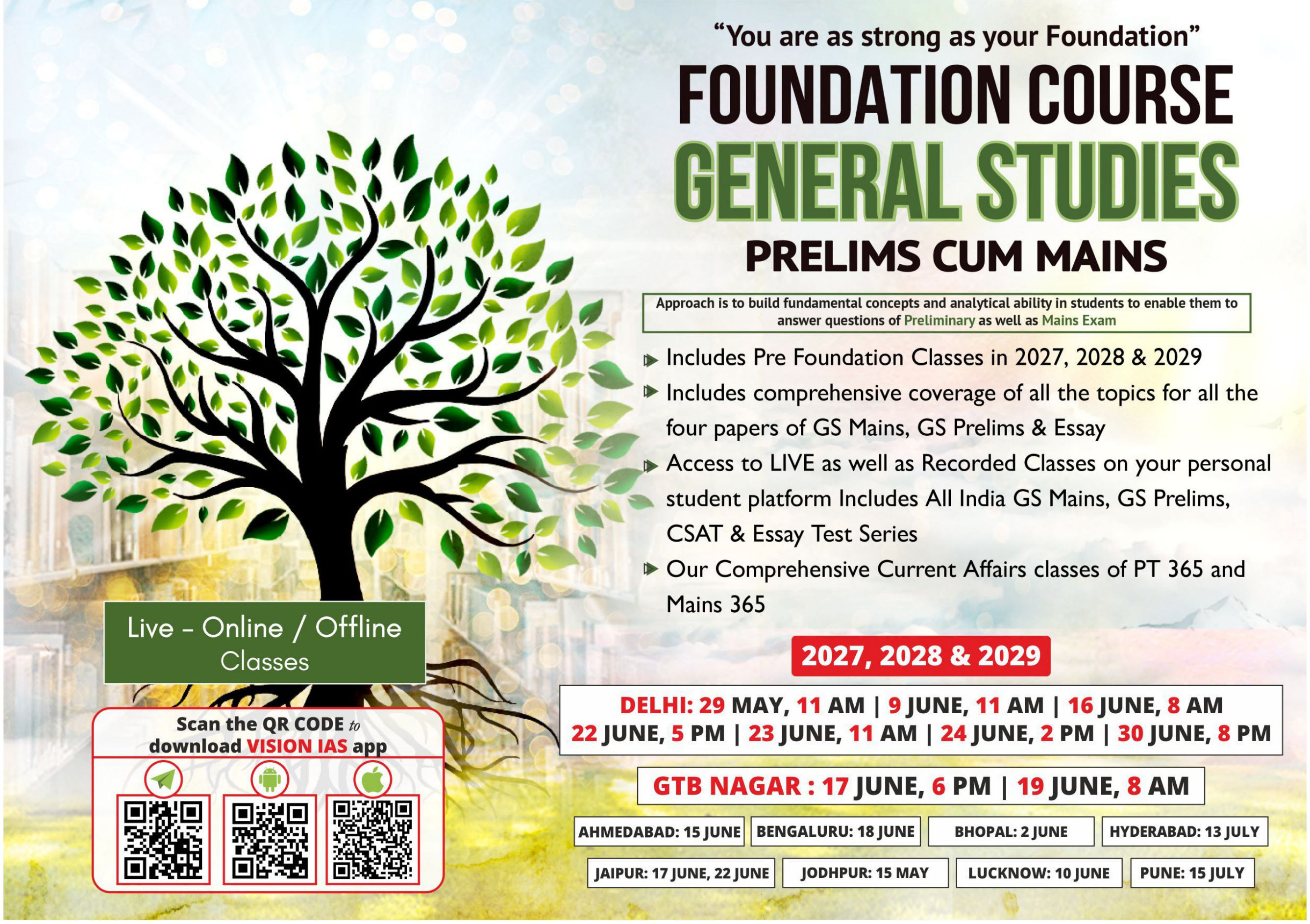
- **Conducting Failure Mode and Effect Analysis (FMEA):** rating every possible hazard on the dimensions of Severity, Frequency of Occurrence, and Difficulty of detection.
    - **E.g.,** learning from Mumbai's efficient handling of the 2024 T20 World Cup roadshow.
- **Crowd Density Norms**: Specify permissible crowd per square metre and evacuation triggers (**e.g.,** barricade breach). E.g., New York mandates trained crowd control managers for events with 1,000+ attendees.
- **Infrastructure Development: E.g.**, Stadiums, ghats, temples must be re-engineered with multiple wide entry/exit points; Multilingual signage and public address systems, etc.
- **Facilities and Emergency Medical Services:** E.g., Maha Kumbh 2025 had articulating water towers (AWT) to prevent and tackle fire incidents, water ambulance, multi-disaster response vehicle etc.
- **Information System: E.g.,** Mobile updates, loudspeakers, Signage, digital boards etc.

How Technology Can Prevent Stampedes in India?

- **RFID & IoT for Crowd Tracking: E.g., Kumbh Mela & Vaishno Devi pilgrimages** have tested RFID tagging for crowd control.
- **Surveillance & Real-Time Crowd Monitoring**
  - **AI-driven CCTV cameras and drones** to analyze crowd density, detect potential bottlenecks and panic movements and guide emergency responses.
    - **E.g., Hajj pilgrimage** uses AI-based crowd monitoring to prevent stampedes.
  - **Drones with thermal imaging** can monitor large gatherings from above.
  - **Live aerial feeds** help command centers make real-time decisions.
- **AI models:** All major events can be logged for identifying crowd patterns, evacuation performance, and logistical gaps to train AI models and improve preparedness in future.
  - **Predictive analytics** can forecast overcrowding and alert authorities before a crisis occurs.

Conclusion

Along with managing crowd through **various technological and administrative measures**, it is essential to bring **about integration of local community resources and people** in response.



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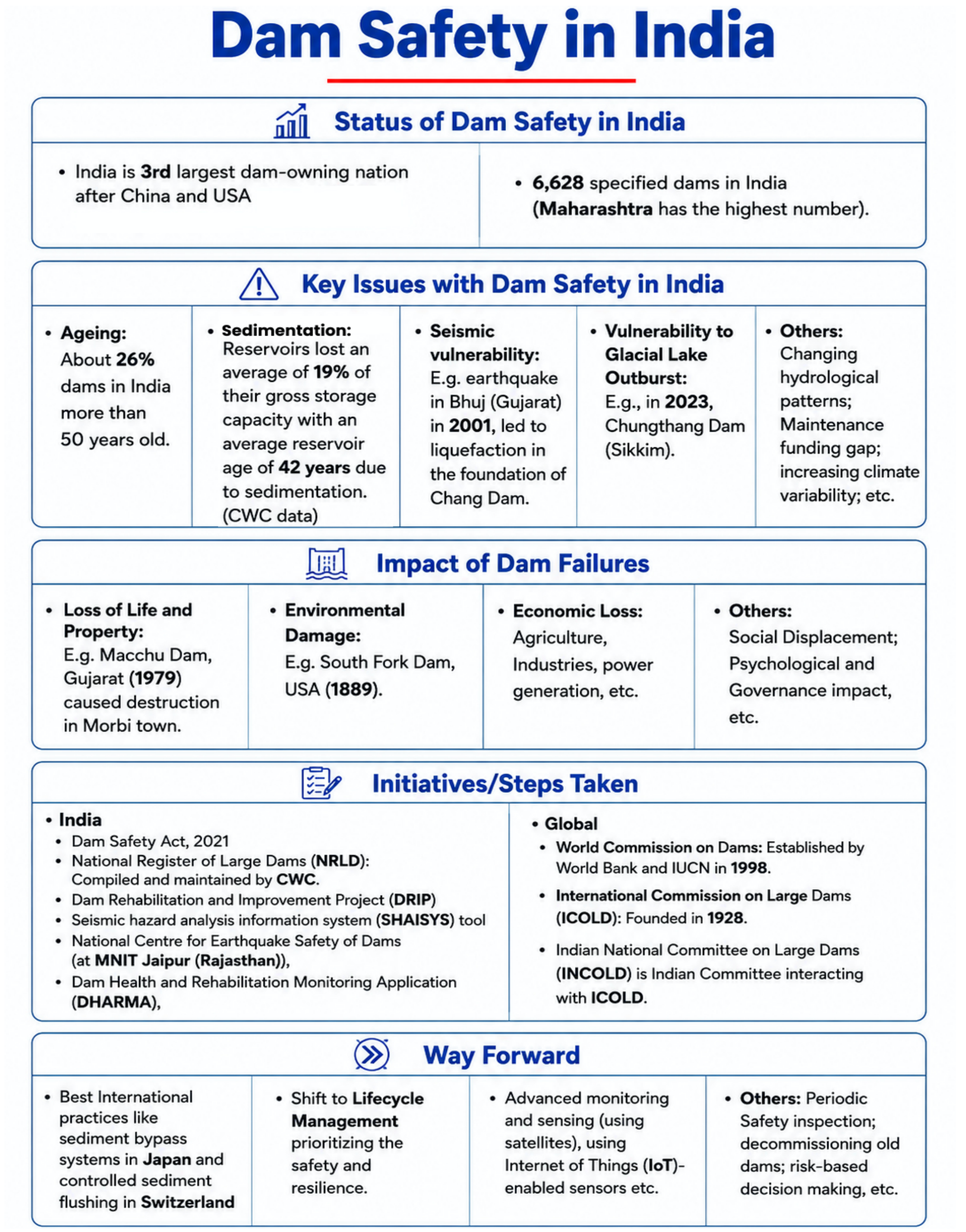
GTB NAGAR : 17 JUNE, 6 PM | 19 JUNE, 8 AM

AHMEDABAD: 15 JUNE | BENGALURU: 18 JUNE | BHOPAL: 2 JUNE | HYDERABAD: 13 JULY
JAIPUR: 17 JUNE, 22 JUNE | JODHPUR: 15 MAY | LUCKNOW: 10 JUNE | PUNE: 15 JULY

6.5. DAM SAFETY IN INDIA AT A GLANCE



Dam Safety in India

Status of Dam Safety in India

- India is **3rd** largest dam-owning nation after China and USA
- **6,628** specified dams in India (**Maharashtra** has the highest number).

Key Issues with Dam Safety in India

- **Ageing:** About **26%** dams in India more than 50 years old.
- **Sedimentation:** Reservoirs lost an average of **19%** of their gross storage capacity with an average reservoir age of **42 years** due to sedimentation. (CWC data)
- **Seismic vulnerability:** E.g. earthquake in Bhuj (Gujarat) in **2001**, led to liquefaction in the foundation of Chang Dam.
- **Vulnerability to Glacial Lake Outburst:** E.g., in **2023**, Chungthang Dam (Sikkim).
- **Others:** Changing hydrological patterns; Maintenance funding gap; increasing climate variability; etc.

Impact of Dam Failures

- **Loss of Life and Property:** E.g. Macchu Dam, Gujarat (**1979**) caused destruction in Morbi town.
- **Environmental Damage:** E.g. South Fork Dam, USA (**1889**).
- **Economic Loss:** Agriculture, Industries, power generation, etc.
- **Others:** Social Displacement; Psychological and Governance impact, etc.

Initiatives/Steps Taken

- **India**
  - Dam Safety Act, 2021
  - National Register of Large Dams (**NRLD**): Compiled and maintained by **CWC**.
  - Dam Rehabilitation and Improvement Project (**DRIP**)
  - Seismic hazard analysis information system (**SHAISYS**) tool
  - National Centre for Earthquake Safety of Dams (at **MNIT Jaipur (Rajasthan)**),
  - Dam Health and Rehabilitation Monitoring Application (**DHARMA**),
- **Global**
  - **World Commission on Dams:** Established by World Bank and IUCN in **1998**.
  - **International Commission on Large** Dams (**ICOLD**): Founded in **1928**.
  - Indian National Committee on Large Dams (**INCOLD**) is Indian Committee interacting with **ICOLD**.

Way Forward

- Best International practices like sediment bypass systems in **Japan** and controlled sediment flushing in **Switzerland**
- Shift to **Lifecycle Management** prioritizing the safety and resilience.
- Advanced monitoring and sensing (using satellites), using Internet of Things (**IoT**)-enabled sensors etc.
- **Others:** Periodic Safety inspection; decommissioning old dams; risk-based decision making, etc.

6.6. GLACIAL LAKE OUTBURST FLOODS (GLOFS)

Why in the news?

India is facing Growing Threats of **Glacial Lake Outburst Floods (GLOFs).**

About GLOFs

- It is **sudden release of water** from a lake fed by glacier melt that has formed at the side, in front, within, beneath, or on the surface of a glacier. E.g. South Lhonak, Sikkim (2023).
    - **Glacial lake** is a body of water formed by melting of glacial ice, typically created in depressions or basins carved out by glaciers during their movement.
- **Status:** > 31,000 of glacial lakes are growing across High Mountain Asia (HMA). [IIT Roorkee].
    - Out of **100 glacial lakes** over **10 hectares in size**, there was an **increasing trend in water spread** area in **34 (CWC).**
- **Impact of GLOFs:** Loss of life and property in downstream villages; destruction of infrastructure like roads; alteration of landscape and river morphology, socio-economic setback, etc.
- **Challenges in Managing GLOFs: Geographical** (difficult and highly accessible terrain); **Technical gaps**; **Anthropogenic** (unplanned infrastructure**); Monitoring Challenges (7,500 glacial lakes are above 4,500 meters)**; **Climate change**, etc.

Major Causes of GLOFs

- **Rising global temperatures**: Globally, since 1990, number, area, and **volume of glacial lakes** have risen **by 53%, 51%, and 48%,** respectively.
- **Glacial Surging**: Sudden movement of ice over short period of time. E.g., Gilkey Glacier, Alaska.
- **Structural Failure: Unstable moraines** (loose debris and ice). E.g. South Lhonak GLOF, Sikkim.
- **Others: Avalanches or landslides** (2021 Chamoli GLOF); **Earthquakes** (Hindu Kush Himalaya); Human Activity, etc.

Mitigation Strategies for GLOFs

- **India**
    - **National GLOF Risk Mitigation Project (NGRMP):** in states of Arunachal Pradesh, Himachal Pradesh, Sikkim and Uttarakhand.
    - **Hazard Mapping: Central Water Commission (CWC)** monitors 900+ glacial lakes and finalized criteria for **Risk Indexing of Glacial Lakes**.
    - **Others**: Early Warning systems through sensors; Structural engineering, etc.
- **Global Initiatives**
    - **Transboundary Cooperation: E.g. Sendai Framework for Disaster Risk Reduction**.
    - **HKH cryosphere initiative:** by International Centre for Integrated Mountain Development (**ICIMOD**)
- **Community-Based Disaster Risk Reduction (CBDRR):** E.g. In the Andes and Alps, Bhutan etc.

Way forward: NDMA Guidelines for Management of GLOFs, 2020

- **Identify Vulnerable Lakes:** Using Remote Sensing and Geographic Information Systems (GIS).
- **Early Warning Systems (EWS):** Utilizing Automatic Water Level Recorders (AWLR), etc.
- **Land-Use Zoning Regulations:** Constitute a specialized committee tailored to GLOF.
- **Structural Risk Reduction:** Structural engineering interventions like controlled breaching, etc.

Conclusion

There is a need for **more integrated and region-specific research** to address the growing risks of GLOFs effectively.

6.7. FIRE SAFETY

Why in the news?

Recent fire tragedies in **Delhi coaching centre, Cuttack (Odisha)**, North Goa's Night Club etc. highlight recurring lapses in fire safety.

Fire Incidents in India

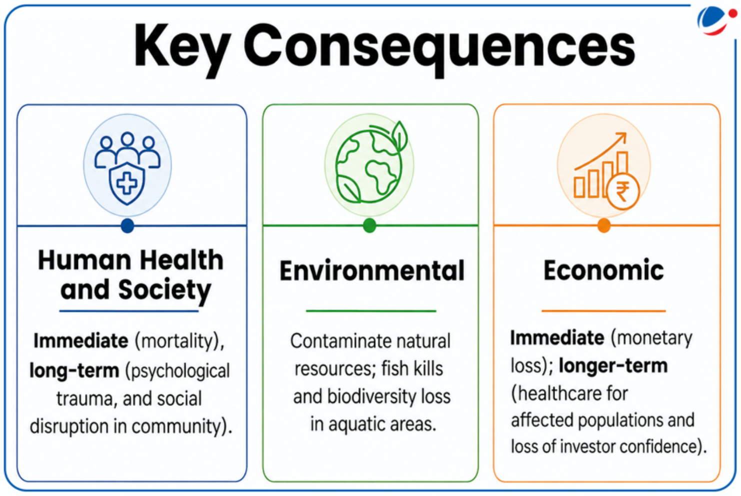
- **5,888 fire-related deaths** were recorded nationally in 2024. (NCRB report)

Fire Safety Regulations in India

- **Constitutional Provisions:** Fire services are **State subject** falling under **12th Schedule (Article 243W)**, assigning responsibility to **Urban Local Bodies**.
- **State Fire Acts**: States enact their own Fire Service Acts to regulate fire safety.
- **National Building Code (NBC), 2016:** Prepared by the Bureau of Indian Standards (BIS), it deals with fire and life safety, covering Fire prevention measures, Fire-safe building design etc.
- **Model Building Bye-Laws, 2016:** By MoHUA to guide States/UTs containing fire safety norms.
- **Institutional Framework**
    - **National Disaster Management Authority (NDMA):** Formulates guidelines for strengthening fire services and promotes modernization, capacity building etc.
    - **Standing Fire Advisory Council (SFAC):** Apex advisory body on fire services under the Ministry of Home Affairs which recommends standards for Fire stations, Equipment and technology, Manpower and training etc.
    - **Scheme for Expansion and Modernization of Fire Services**: Implemented by Home Ministry based on 15th Finance Commission recommendations to strengthen fire infrastructure and capacity.

Reasons behind Fire Safety Lapses in India

- **Hot temperatures and dry conditions** increase fire risk. **E.g., Brahmapuram waste plant fire, Kochi (2023).**
- **Unsafe Urban Design & High Density** like Mixed land use, congestion, and illegal constructions. **E.g. Delhi commercial-cum-residential building fire (2026).**
- **Structural Violations** like Poor building materials, altered designs and ineffective electrical systems increase vulnerability. **E.g. Cuttack hospital fire (2026)**
- **Non-compliance of National Building Code**, lack of fire exits, faulty safety systems, and irregular fire audits. E.g. **coaching centre Mukherjee Nagar (Delhi) fire (2023)**
- **Other Factors:** Chronic shortage of trained firefighting personnel, Electrical short circuits, poor maintenance, low public awareness, shortage of fire infrastructure, etc.



Key Consequences

Human Health and Society

Immediate (mortality), **long-term** (psychological trauma, and social disruption in community).

Environmental

Contaminate natural resources; fish kills and biodiversity loss in aquatic areas.

Economic

Immediate (monetary loss); **longer-term** (healthcare for affected populations and loss of investor confidence).

Way forward

- **NDMA Guidelines:**
    - **Enactment of a Fire Act at state level** for mandatory clearance from the fire department for certain buildings and premises.
    - **Improve the outreach of the Fire Services** to the block and the Gram Panchayat level.

  - **Professional Head of fire services** at the state level and district level (chief fire officer).
  - **Research & Development** of indigenous, less water-consuming fire extinguishing technologies.
- **Other steps**
  - **Mandatory third-party Fire Safety Audits**, proper scrutiny before sanctioning NOCs.
  - **Community Awareness and Participation:** E.g. China's strict enforcement and community-based fire prevention programs.
  - **Technological Integration:** AI-based **Hazard Identification & Risk Assessment (HIRA)**, etc.
  - **Secure Funding:** E.g. Introduction of Fire Tax for upgrading equipment, infrastructure etc.

Conclusion

Fire safety practices should include **preventing ignition, planning safety before construction, and response post occurrence**. It must ensure that people associated should have a **working knowledge of basic fire science and chemistry.**

6.8. EXTREME HEAT

Why in the news?

A study by Council on Energy, Environment (CEEW), assessed **heat risk across 734 districts in India** and finds majority of Indian population faces high to very high risk.

About Heat Risk vs. Heatwaves and Heat Stress

- **Heatwaves: Prolonged periods** of abnormally high temperatures in **a specific region (e.g.,** plains, coastal areas, hills).
- **Heat Stress:** Occurs when body temperature rises **beyond 37°C**, leading to discomfort, cramps, and potentially fatal heat strokes.
- **Heat Risk:** Probability of **experiencing heat-related illnesses** or **death** due to **exposure to extreme temperatures.**
- **Depends on: Intensity of Heat** (compounded by humidity)**; Degree of Exposure; Vulnerabilities** of affected communities.

Heatwave Declaration in India

- **Declared by:** India Meteorological Department (IMD)
- **Criteria:** Declared when the temperature of a place crosses 40 degrees Celsius (°C) in the plains, 37°C in the coastal areas and 30°C in the hills. Further, it uses following criterion:
- **Based on departure from Normal Temperature**
  - **Heat Wave**: Between 4.5°C to 6.4°C from normal
  - **Severe Heat** Wave: >6.4°C
- **Based on departure from Actual Maximum Temperature (for plains only)**
  - **Heat Wave:** ≥ 45°C
  - **Severe Heat Wave**: ≥47°C

Factors Driving Heat Risk

- **Increase in Warm Nights (2012-22) over warm days:** Higher temperatures during night makes **it difficult for body to cool** down after intense daytime heat.
- **Increase in Humidity in North India:** North India's humidity rose from **30-40% (1982-2011)** to **40-50% (2012-22)** limiting the body's cooling through sweat.
- **Rapid urbanization:** In cities like Mumbai, Delhi, Pune, and Gurugram have caused **'urban heat island effect'**
  - **Urban heat island effect:** Phenomenon where concrete infrastructure absorbs and retains heat.

Impact of Extreme Heat

- **Primary Threat to Species:** Projected to expose **93% of species' geographic ranges** by 2085, followed closely by extreme wildfires.
- **Food Security Risk:** Major threat to **Indian rice and wheat production**, with **Ganges and Indus River basins** facing the most intense risks.
- **Threats to Agricultural Workers: Wet bulb temperature extremes** could lead to **40% fall in work capacity** by end of 21st century.

Way Forward

- **Expand Heat risk planning** taking into consideration warm nights along with daytime temperatures.
- **Use of State Disaster Funds**: Ministry of Home Affairs included heatwaves as nationally eligible disaster for SDMF project-based funding.
- **Declaring them as disasters in states** where >50% districts face high heat risk.
- **Create National Heat Action Plan Repository** to improve transparency and monitoring.
- **On-Farm Adaptation**: Like **heat-tolerant crops and livestock breeds**, improved irrigation and shading.

Conclusion

Extreme heat adaptation presents a **frontier for innovation across policy, technology, and finance** spanning **research and development in passive cooling**, and **early warning systems** to anchor a new **"cool economy,"** for India.

6.9. KEYWORDS

Disaster Risk Reduction (DRR)	Community-based DRR	Urban Resilience	Coastal Vulnerabilities	Hindu Kush Himalayan Region
Stampedes	Heat Risks	Fire Safety	Seismic Zones	Glacial Lake Outburst Floods (GLOFs)
Multi-Hazard Early Warning Decision Support System	Heat Stress	Disaster Risk Index (DRI)	Risk transfer	Heatwaves

6.10. PRACTICE QUESTION

What the key reasons for the occurrence of crowd disasters like stampede as witnessed recently. What measures should be taken to manage them?

Introduction	Body Part 1	Body Part 2	Conclusion
Give an example of few such incidents like in Bengaluru.	Mention the key reasons for their occurrence.	Suggest measures taken to manage them including NDMA guidelines.	Provide a brief futuristic way forward like incorporating technological use.

7. GEOGRAPHY

7.1. BHARAT FORECAST SYSTEM (BFS)

Why in the News?

Ministry of Earth Sciences unveils BFS, one of world's first indigenously developed high-resolution weather forecast systems.

About Bharat Forecast System

- **Developed by:** Indian Institute of Tropical Meteorology (IITM), Pune, an autonomous institute of the Ministry of Earth Sciences.
- **Role:** Enhances **India's weather prediction resolution from 12 km to 6 km**.
- **Data Sources:** Integrates real-time inputs from 40 Doppler Weather Radars, improving accuracy.
    - **Doppler Radar** uses **doppler effect** (Change in frequency of wave emitted by a source moving relative to the observer) to gather velocity data from particles being measured.

Significance of BFS

- **Delivers 64% better accuracy** in high-risk zones and produces forecasts **within 4–6 hours**.
- **Positions India ahead of countries** like US, UK, and EU by achieving 6 km resolution (compared to 9–14 km in global models).
- **Support for Disaster Management & Agriculture** through tailored short range and nowcasts at village and block level; assistance to farmers, coast communities, etc.
- **Reduce climate-related losses** in sectors like agriculture, infrastructure.
    - Powered by **High-Performance Computing (HPC) systems** – Arka (IITM Pune) and Arunika (National Centre for Medium Range Weather Forecasting, Delhi) – to deliver faster simulations
- **More accurate forecasting** of tropical disturbances, monsoons, cyclones, etc.

Conclusion

BFS reflects India's growing self-reliance in critical scientific infrastructure highlighting resilience and inclusive development in times of rising climate risks.

7.2. SUPER EL NINO

Why in the news?

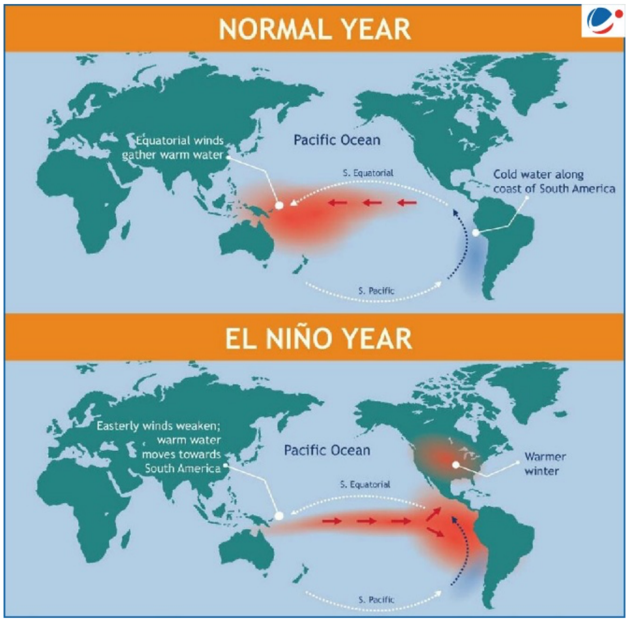
Forecasts of a **potential "super" El Niño in late 2026** have raised concerns over intensified heatwaves, droughts, floods, and extreme weather events.

About Super El Nino

- An exceptionally **strong El Niño event** in which **sea surface temperatures in the central and eastern equatorial Pacific rise by more than 2°C** above normal for a sustained period.

About El Nino Southern Oscillation (ENSO)

- **Recurring natural phenomenon characterised by fluctuating ocean temperatures in the equatorial Pacific**, coupled with changes in the atmosphere


NORMAL YEAR
Equatorial winds gather warm water
Pacific Ocean
S. Equatorial
Cold water along coast of South America
S. Pacific
EL NIÑO YEAR
Easterly winds weaken; warm water moves towards South America
Pacific Ocean
Warmer winter
S. Equatorial
S. Pacific

- **El Nino and La Nina** are the oceanic components, while the **Southern Oscillation** is atmospheric counterpart of the system.

La Nina Phase

- **Meaning:** Cold phase of ENSO occurs when trade winds strengthen, pushing warm water further west toward Asia and allowing cold water to rise in eastern Pacific.
    - Berkeley Earth's Annual Temperature Report finds 2025 warmest La Nina year on record
- **Impact on India:**
    - **Monsoon:** Generally beneficial, bringing normal to above-normal rainfall, supporting agriculture.
    - **Winter:** Triggers colder-than-normal winters and frequent cold waves in northern India.
    - **Extreme Events:** Increased risk of floods and severe cyclonic activity in Bay of Bengal.

El Nino Phase

- **Meaning:** Warm phase of ENSO occurs when trade winds weaken, allowing warm water to move toward South America.
- **Impact on India:**
    - **Monsoon:** Typically weakens southwest monsoon, often leading to below-normal rainfall or droughts.
    - **Agriculture:** Suppresses yields for summer crops like rice, sugarcane, and oilseeds increasing food prices.
    - **Heat:** Associated with harsher summers and increased heat stress.

Conclusion

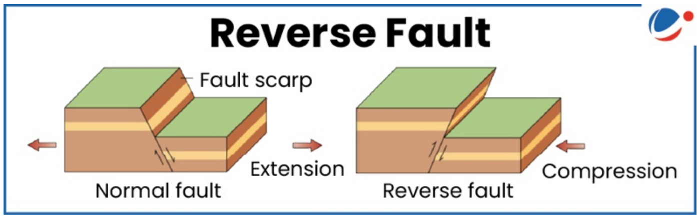
Early warning systems and **anticipatory action** can help reduce the impacts of extreme weather conditions exacerbated by ENSO.

7.3. PACIFIC RING OF FIRE

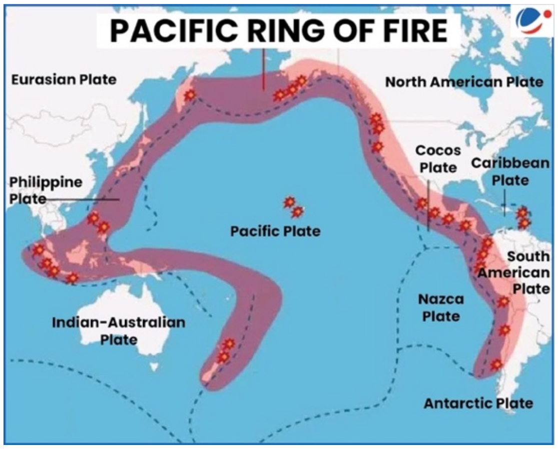
Why in the News?

Powerful magnitude 8.8 earthquake struck near Russia's Kamchatka Peninsula part of seismically active **Pacific Ring of Fire** triggering tsunami waves that hit coastal towns in Russia and Japan.

More on the news


Reverse Fault
Fault scarp
Extension
Normal fault
Reverse fault
Compression

- Scientists believe quake was caused by **shallow reverse faulting**.
- **Reverse faulting (or thrust faulting)** occurs when one block of Earth's crust is pushed up over another due to **compressional forces.**
- **"Shallow" Reverse faulting** means rupture occurred near Earth's surface.
    - Can cause strong ground shaking, powerful aftershocks, tsunamis, and serious damage to infrastructure.


PACIFIC RING OF FIRE
Eurasian Plate
North American Plate
Cocos Plate
Caribbean Plate
Philippine Plate
Pacific Plate
South American Plate
Nazca Plate
Indian-Australian Plate
Antarctic Plate

About Pacific Ring of Fire

- Or Circum-Pacific Belt, is a **horseshoe-shaped belt** of intense seismic and volcanic activity encircling Pacific Ocean basin.
- **It accounts for:**
    - **~75% of the world's active** volcanoes
    - **~90% of the world's** earthquakes
- **Location & Extent**
    - ~40,000 km around the Pacific Ocean.

  - Traces boundaries between several tectonic plates including the Pacific, Juan de Fuca, Cocos, Indian-Australian, Nazca, North American and Philippine Plates.

Features of Circum-Pacific Belt:

- **Geography:** Mountains, island arcs, deep underwater trenches, like Mariana Trench (world's deepest spot).
- **Source of geothermal energy:** Storing >40% of global geothermal energy resources.
- **Minerals:** Home to rich mineral deposits like gold, copper, molybdenum, and other metals.
- **Agricultural Significance:** Volcanic soils are fertile (good for crops like rice, coffee)

Cause of Frequent Earthquakes and Volcanism along pacific ring of fire

- **Subduction zones:** Tectonic plates overlap at **convergent boundaries** (subduction zones).
  - E.g. Taupo Volcanic Arc, near New Zealand where dense Pacific Plate is **subducting beneath Australian Plate.**
- **Zone of transform boundary/fault:** Like San Andreas Fault (California), plates slide past each other laterally generating shear motion suitable for volcanism and earthquakes.
- **Mid-oceanic Ridges/Divergent Boundaries:** Tectonic plates pulling apart create seafloor spreading and rift valleys. E.g. East Pacific Rise
- **Hot Spots:** Areas deep in Earth's mantle where rising heat melts rock in upper mantle pushing up magma for volcanism.

Conclusion

The Ring of Fire exemplifies **Earth's dynamic geology**, where converging tectonic processes create the vast majority of global volcanic eruptions and seismic activity.

7.4. MONSOON-RELATED EXTREME WEATHER EVENTS

Why in the News?

Recent events like Punjab floods, **landslides and flash floods** in Uttarakhand, Himachal Pradesh and J&K highlight **growing frequency and intensity of monsoon-related extreme weather events.**

Changing nature of Monsoon

- **Erratic patterns of rainfall:** Research suggests that monsoon winds are weakening.
  - However, rising temperatures are increasing atmospheric moisture, creating **more intense bursts of rainfall separated by frequent dry spells.**
- **Changing El Niño-monsoon relationship: Weakening** correlation between El Niño and reduced monsoon rainfall over India due to changes in global atmospheric circulation patterns.
- **Spatial distribution of monsoon: Humid** regions are becoming **drier** and dry regions are becoming wetter.
  - E.g., decreasing rainfall along **Ganga basin states** while increasing rainfall in **Gujarat's Saurashtra, Rajasthan.**
- **Climate change: Rising sea levels and temperatures** result in changes in monsoon patterns, increasing **water vapour holding capacity of clouds,** impacting intensity of rainfall.

Impact of Changing Monsoon Patterns in India

- **Disasters:** Intense, short-period rains cause loss of lives, damage infrastructure, strain disaster management.
- **Health:** Rising disease risks (heat stress, dengue) and reduced productivity.
- **Forecasting:** Rainfall variability and climate change hinder accurate predictions.
- **Economic**: Affects 51% of farmed area, 40% of agricultural output, and 47% of livelihoods.

Conclusion

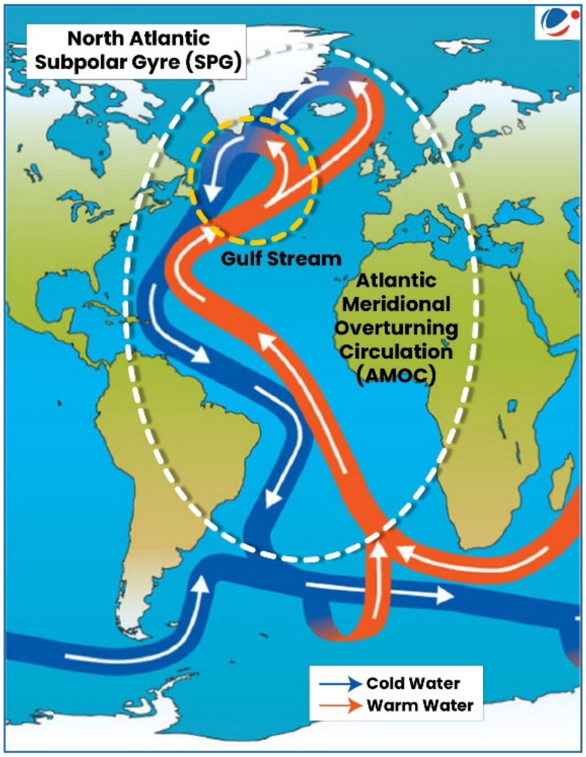
Shift in monsoon patterns mandate shift from **post-disaster response** to **pre-disaster focus** on reducing vulnerabilities through **sustainable infrastructure and effective early-warning systems.**

7.5. ATLANTIC MERIDIONAL OVERTURNING CIRCULATION (AMOC)

Why in the News?

Recent study warned of **potential collapse of AMOC,** having profound impact on global climates.

What is Atlantic Meridional Overturning Circulation (AMOC)?


North Atlantic Subpolar Gyre (SPG)
Gulf Stream
Atlantic Meridional Overturning Circulation (AMOC)
Cold Water
Warm Water

- System of **ocean currents** that circulates water within Atlantic Ocean, bringing warm water north and cold water south.
- Driven by **differences in temperature and salinity**, creating differences in water density, a process known as **thermohaline circulation**.
- **Process**:
  - AMOC brings **warm, salty water** from **Gulf of Mexico** to **north Atlantic**, keeping temperatures in **western Europe milder** than in Canada or Russia.
  - **Dense water** then **cools and sinks**, moving **south** on the seafloor along the western Atlantic.
  - It eventually **rises** again through **upwelling**, **warms** up, and restarts the cycle.
- **Significance**: Part of large **"global conveyor belt,"** circulates **water, heat, and nutrients** throughout Atlantic Ocean.
- **Reason for Collapsing AMOC**: Climate change induced Greenland's melting ice sheet added ~5,000 km^3 of freshwater into Subpolar North Atlantic Ocean reducing density and salinity, slowing down sinking of water, resulting in weakening of AMOC.

Potential implications of collapse of AMOC

- **Climate Disruption: Weakening AMOC could be a climate tipping point**, with global consequences-
  - **Extreme Cooling of Europe**: E.g. AMOC collapse could **cool Arctic** region by ~7 °C.
    - May turn **Southern Ocean** from **carbon sink into a source.**
  - **Change precipitation patterns:** while AMOC helps **balance heat** between hemispheres, its collapse would shift **tropical rain belt southward**, potentially causing:
    - **Droughts** in the Sahel (Africa) and parts of South Asia.
    - **Disruption of Monsoons** in India, which are vital for food security.
  - **Marine Ecosystem Collapse**: Fewer nutrients reach surface waters, harming **marine food chains**.

7.6. KEYWORDS

Bharat Forecast System	Pacific Ring of Fire	Reverse Faulting	Extreme weather events
Super El Nino	Atlantic Meridional Overturning Circulation (AMOC)	Climate tipping point	ENSO

7.7. PRACTICE QUESTION

<table>
<tr><td colspan="4">What factors indicate towards the changing pattern of monsoon as evident in recent instances of extreme events. Mention the impact of such a phenomenon.</td></tr>
<tr><td>Introduction</td><td>Body Part 1</td><td>Body Part 2</td><td>Conclusion</td></tr>
<tr><td>Provide example of recent monsoon related extreme weather events.</td><td>Discuss the key factors/events indicating towards changing pattern of monsoon.</td><td>Discuss the impact of such change.</td><td>Conclude briefly by suggesting change in response strategy commensurate with it.</td></tr>
</table>

फाउंडेशन कोर्स
सामान्य अध्ययन
प्रारंभिक एवं मुख्य परीक्षा 2027
इनोवेटिव क्लासरूम प्रोग्राम

- प्रारंभिक परीक्षा, मुख्य परीक्षा और निबंध के लिए महत्वपूर्ण सभी टॉपिक का विस्तृत कवरेज
- मौलिक अवधारणाओं की समझ के विकास एवं विश्लेषणात्मक क्षमता निर्माण पर विशेष ध्यान
- एनीमेशन, पॉवर प्वाइंट, वीडियो जैसी तकनीकी सुविधाओं का प्रयोग
- अंतर - विषयक समझ विकसित करने का प्रयास
- योजनाबद्ध तैयारी हेतु करेंट ओरिएंटेड अप्रोच
- नियमित क्लास टेस्ट एवं व्यक्तिगत मूल्यांकन
- प्री फाउंडेशन कक्षाएं
- सीसैट कक्षाएं
- PT 365 कक्षाएं
- MAINS 365 कक्षाएं
- PT टेस्ट सीरीज
- मुख्य परीक्षा टेस्ट सीरीज
- निबंध टेस्ट सीरीज
- सीसैट टेस्ट सीरीज
- निबंध लेखन - शैली की कक्षाएं
- करेंट अफेयर्स मैगजीन

नोट: ऑनलाइन छात्र हमारे पाठ्यक्रम की लाइव वीडियो कक्षाएं अपने घर पर ऑनलाइन प्लेटफॉर्म पर देख सकते हैं। छात्र लाइव चैट विकल्प के माध्यम से कक्षा के दौरान अपने संदेह और विषय संबंधी प्रश्न पूछ सकते हैं। वे अपने संदेह और प्रश्न नोट भी कर सकते हैं और दिल्ली केंद्र में हमारे कक्षा सलाहकार को बता सकते हैं और हम फोन/मेल के माध्यम से प्रश्नों का उत्तर देंगे।

DELHI : 16 जून, 8 AM
JAIPUR : 18 मई & 22 जून
JODHPUR : 15 मई

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8. APPENDIX: KEY DATA AND FACTS

Climate Change	
UNFCCC COP30	**Key Outcomes:** • **195 Parties** adopted Belem Package. • **Baku to Belém Roadmap: Mobilize New Collective Quantified Goal (NCQG**) of **$1.3 trillion/year by 2035.** • **Tropical Forest Forever Facility (TFFF):** $125B Tropical Forest Investment Fund (TFIF) • **Tripling of adaptation finance:** To **$120 billion per year.** • **Belém 4x Pledge on Sustainable Fuels:** Quadruple use of sustainable fuels (hydrogen, biofuels, e-fuels) by 2035 compared to 2024 levels. • **Belém Health Action Plan:** World's first climate adaptation plan dedicated to health. • **Others:** Scaling J-REDD+ (Jurisdictional Reducing Emissions from Deforestation and forest Degradation+), Food Waste Breakthrough, Global Mutirão Against Extreme Heat / Beat the Heat Implementation Drive, etc. **India's Position:** • **Common but Differentiated Responsibilities (CBDR-RC)-** cornerstone of global climate regime. • **Implementation of Article 9.1** is a legal obligation for developed countries. • **Technology Access is a Right**, not a Bargaining Tool.
India's Updated Nationally Determined Contribution (NDC)	**Updated Targets for 2035** • **Reduction in Emissions Intensity of GDP (from 2005 levels):** 47% (Progress- 36% reduction achieved by 2020) • **Cumulative electric power installed capacity from non-fossil fuel-based energy resources:** 60% (Progress- 52.57% achieved by February 2026) • **Additional Carbon Sink through forest and tree cover (from 2005 levels):** 3.5–4 billion tonnes (Progress- 2.29 billion tonnes equivalent by 2021)
Climate Change Impacts	• **Glacier Preservation:** ○ **Melting rate doubled** since 2000 with Ganga and Brahmaputra basins witnessing reduction of 21% and 16% respectively. (ICIMOD); ○ **Dead glaciers**: Yala Glacier, Nepal (2025); Ayoloco glacier, Mexico (2021); etc. • **Climate Change and Oceans:** ○ Global average **Sea Surface Temperatures in 2025 among highest ever recorded** (**~0.5°C above 1981–2010 average).** ○ **Ocean acidification** breached planetary boundary • **Health and Climate change: Belem Action Plan for Health and Climate Adaptation** launched at **COP30 in Belem, Brazil.** ○ Over 540 000 people dying from extreme heat each year.
Carbon Market	• **Types:** Emissions Trading Systems (ETS), Carbon Taxes, Carbon Crediting Mechanisms • **Key Facts (Status and Trends of Carbon Pricing 2026)** ○ Carbon pricing policies **cover 29% of global GHG.** ○ Carbon taxes and ETS **generated over $107 billion in 2025.**
Greenhouse Gases Emission Intensity Target (Amendment) Rules, 2025	**Key Provisions** • **Covered sectors**: Petroleum Refinery, Petrochemicals, Textiles, and Secondary Aluminium**,** Aluminium, Cement, Chlor-alkali, and Pulp & Paper. • **Emission intensity reduction targets:** 3% - 7% by 2026-27 (baseline: 2023-24).

	• **Legally binding rules notified under:** Carbon Credit Trading Scheme (CCTS), 2023 (under Energy Conservation Act, 2001) • **Compliance Enforced by**: Central Pollution Control Board (CPCB)
Green Credit Program (GCP)	• **Established under**: Environment (Protection) Act, 1986 • **Revised Norms under Green Credit Rules, 2023** o **Claim of Green Credit:** After 5 years of restoration on degraded forest land and achieving **at least 40% canopy** density o **Credits** are **non-tradable and non-transferable**
Carbon Capture, Utilization and Storage (CCUS)	• Union Budget 2026-27 announced allocation of **Rs 20,000 crore** over next 5 years. • **Capture techniques**: **Direct Air Capture (DAC), solvents** (chemical or physical), **Adsorption, Cryogenic separation** etc • **India's Target:** 750 mtpa (Million Tonne Per Annum) of CO_2 capture, utilization, and storage (NITI Aayog).
NITI Aayog Report: Scenarios Towards Viksit Bharat and Net Zero:	• **Historical Contribution:** India's per-capita GHG emissions stand at **2.9 tCO2e**, (global average 6.7 tCO2e). • **Share of Fossil Fuel (**2024-25): Supplied **87% of India's total primary energy-** coal (54%) and oil (26%). • **Financing Needs towards Net Zero: USD 22.7 trillion by 2070** to align with the Net Zero Scenario **(NZS).** o **Financing Gap:** $6.5 trillion by 2070. • **Sectoral Needs** o **Agriculture Sector: Share in India's GHG emissions: ~**14% (predominantly methane from livestock/rice). o **Power Sector: Share in India's GHG emissions is** ~75%. > **Projected increase in electricity demand:** 4-5 times by 2050 and 6-8 times by 2070 over 2025 levels. o **Waste Sector:** > **Annual Waste Generation**: 62 million tonnes (TERI study); **Projected to rise to**165 MT by 2030. (CPCB) > **Emission from waste (2020)**: 2.56% of India's total emissions. (4th Biennial Update Report)
Industrial Decarbonisation	• **Contribution to India's total GHG emissions:** Cement sector: ~6%; Aluminium sector: ~2.8 % o **MSMEs** Contributed ~**135 million tonnes** of carbon emissions in 2022.
Methane Emissions	• **Methane's atmospheric Concentrations doubled** since pre-industrial times reaching ~**352 million tonnes (Mt) per year in 2020.** • India is **world's third-largest methane emitter.**
Ozone Depletion and Montreal Protocol	• **Ozone layer expected to recover to 1980 values** (before ozone hole appearance) by **around 2066 over Antarctic**, by 2045 over Arctic and by **2040 for rest of the world**. • **Montreal Protocol:** Parties agreed to **reduce HFCs by 80–85% by the late 2040s**. • **India's progress**: o Phased out chlorofluorocarbons (CFCs), carbon tetrachloride (CTC), and halons for controlled use by 2010. o Achieved **67.5% reduction in HCFC production & consumption** and complete phase out of **HCFC-141b (2020).** o Will achieve cumulative reduction **of 10% (2032), 20% (2037), 30% (2042) and 85% (2047).**
Land Based Carbon Removal (LBCR)	• Climate pledges require 1 billion ha of land. (Land Gap Report 2025)

Carbon Border Adjustment Mechanism (CBAM)	• Implemented by EU from 2026; CBAM tax burden would **represent 0.05% of India's GDP.**
Environmental Pollution And Degradation	
Air Pollution	• **Urban Air Pollution: India is 6th most polluted country** in world, has **66 of world's 100 most polluted cities.** (IQAir World Air Quality Report 2025). • **Key Contributors to Delhi Pollution**: Secondary Particulate Matter (27%); Transport (23%); biomass burning (20%); dust (15%); **industry** including thermal power plants (**9%).** • **Cloud seeding:** Chemicals used- Silver iodide, potassium iodide, dry ice, etc.
Water Governance	• Water is a **State subject** under 7th schedule, Regulation and development of **Inter-State rivers** is a **Union Subject.** • India's water demand will double available supply by 2030 (NITI Aayog), while groundwater depletion could triple by 2041–2080.
Water Bankruptcy	• India holds 18% of the world's population, but **only 4% of its freshwater resources** • **Average per capita water availability** is expected to **reduce 1140m^3 by 2050** (classified as water stress). (National Commission on Integrated Water Resources Development (NCIWRD) report)
River Pollution in India	**Polluted River Stretches (PRS) for Restoration of Water Quality – 2025** • **296** polluted stretches on 271 Rivers (in 623 rivers analysed). • **62% locations complied Bio-Chemical Oxygen Demand (BOD) criteria** (less than 3.0 mg/L). **Status of Trace and Toxic Metals 2024:** By Central Water Commission- • At **112 stations** (out of 434 studied), at least 1 metal (out of 9) found beyond limit.
Groundwater Extraction in India	**National Compilation on Dynamic GW Resources of India 2025** • **Over-exploited units:** 10.8% • **Total Annual Ground Water Extraction (2025):** Marginally increased to 247.22 BCM
Ground Water Pollution in India	**CGWB's Annual Groundwater Quality Report 2025** • **28.3%** of samples of India's groundwater exceed limits for one or more parameters of BIS standards
Solid Waste Management	• **Key provision of Solid Waste Management (SWM) Rules, 2026:** ○ **Four-stream** Segregation of Solid Waste at Source (Wet, dry, Sanitary and Special Care Waste). ○ **Use of Refuse Derived Fuel (RDF) by Industries** ○ **Mandatory Annual audits of landfills** ○ **Environmental Compensation (EC): 'Polluter Pays' principle** for non-compliance • **Status of Solid waste** ○ **Total waste generation** projected to increase to **165 million tonnes by 2030** and **436 million tonnes by 2050.** ○ Only **60-70%** of waste is **collected,** and merely **15-20%** is **processed.**
Plastic Pollution	• **Key Provisions of Plastic Waste Management (Amendment) Rules, 2026:** ○ Producers, importers, and brand **owners mandated to use higher amounts of recycled plastic in packaging.** ○ **Explicitly defines terms** like "**end of life disposal**," "**reuse**," and "**Plastic Waste Processors;** ○ **Decentralised enforcement** by Urban Local Bodies (ULBs). • **Extent:** >**460 million metric tons** of plastic produced annually (WEF).

E-Waste	• India is **3rd largest e-waste** generator globally. • **E-waste generation increased** from ~2.76 MMT (2020) to ~6.19 MMT (2024) ○ Projected to reach 14 MMT by 2030
Sustainable Development	
Sustainable Development Goals (SDGs)	• **India** ranked among top **100 in SDG Index at 99** (Score 67 out of 100) **in SDR 2025.** • **Financing for SD: Sevilla Commitment** to close **$4 trillion annual SDG financing gap in developing countries.** ○ **Financing Gap** reached **4 trillion US dollars annually** (UN estimates).
Environment Impact Assessment (EIA)	• Key Facts about EIA: ○ **Principal regulatory framework:** EIA Notification, 2006, under Environment Protection Act 1986 for granting Environmental Clearance (EC). ○ **Mandatory** for projects above Rs 50 crores ○ **Steps in EIA**: Screening -> Scoping ->Public Consultation -> Decision Making -> Monitoring • **Public Consultation: MoEFCC** exempted **mining projects** involving **Atomic, Critical,** and **Strategic minerals (like Rare Earth Elements)** from **Public Consultation.**
Environment Audit Rules, 2025	**Key Provisions** • **Developed under:** Environment Protection Act (1986). • **Environment Audit Designate Agency (EADA)** responsibilities include certification, registration, oversight, and training of auditors. • Auditing to be undertaken only by **Registered Environment Auditors (EAs).** • **Environment Auditors (EAs)** will be certified and registered by Environment Audit Designate Agency (Notified by MoEFCC)
Sustainable Agriculture in India	• **Agroforestry:** ○ **Definition: Land use system** integrating **trees and shrubs** on farmlands and rural landscapes to enhance productivity, profitability, diversity and ecosystem sustainability. (National Agroforestry Policy 2014). ○ Occupies ~**8% of India's geographical land area**. • **Climate Resilient Agriculture:** ○ **Definition: Adopting adaptation and mitigation practices** in agriculture to enhance system's ability **to withstand climate shocks and recover quickly.** ○ Climate change can reduce yields by **4.5 to 9.0%** resulting around **1.5% GDP** loss per year. (Parliamentary standing committee on agriculture)
Circular Economy	• **Definition:** Economic system that uses a **systemic approach** to maintain a **circular flow of resources** by **recovering, retaining, or adding to their value**, while contributing to sustainable development (International Organization for Standardization). • **Potential In India is** Market value of over **$2 trillion and 10 million jobs** by **2050.**
Great Nicobar Island Project	• **Nodal Agency:** Andaman and Nicobar Islands Integrated Development Corporation (ANIIDCO), incorporated in 1988 as a **Government Undertaking under the Companies Act 1956**. • **Project Components: International Transshipment Port: Galathea Bay:** Deep-sea port on island's southern coast; **Greenfield international airport; 450 MW** power plant etc.
Illegal Sand Mining in India	• **Sand: World's** second most exploited natural resource after water (UNEP). • Sand is a **minor mineral** under **Mines and Minerals (Development and Regulation) Act, 1957.**

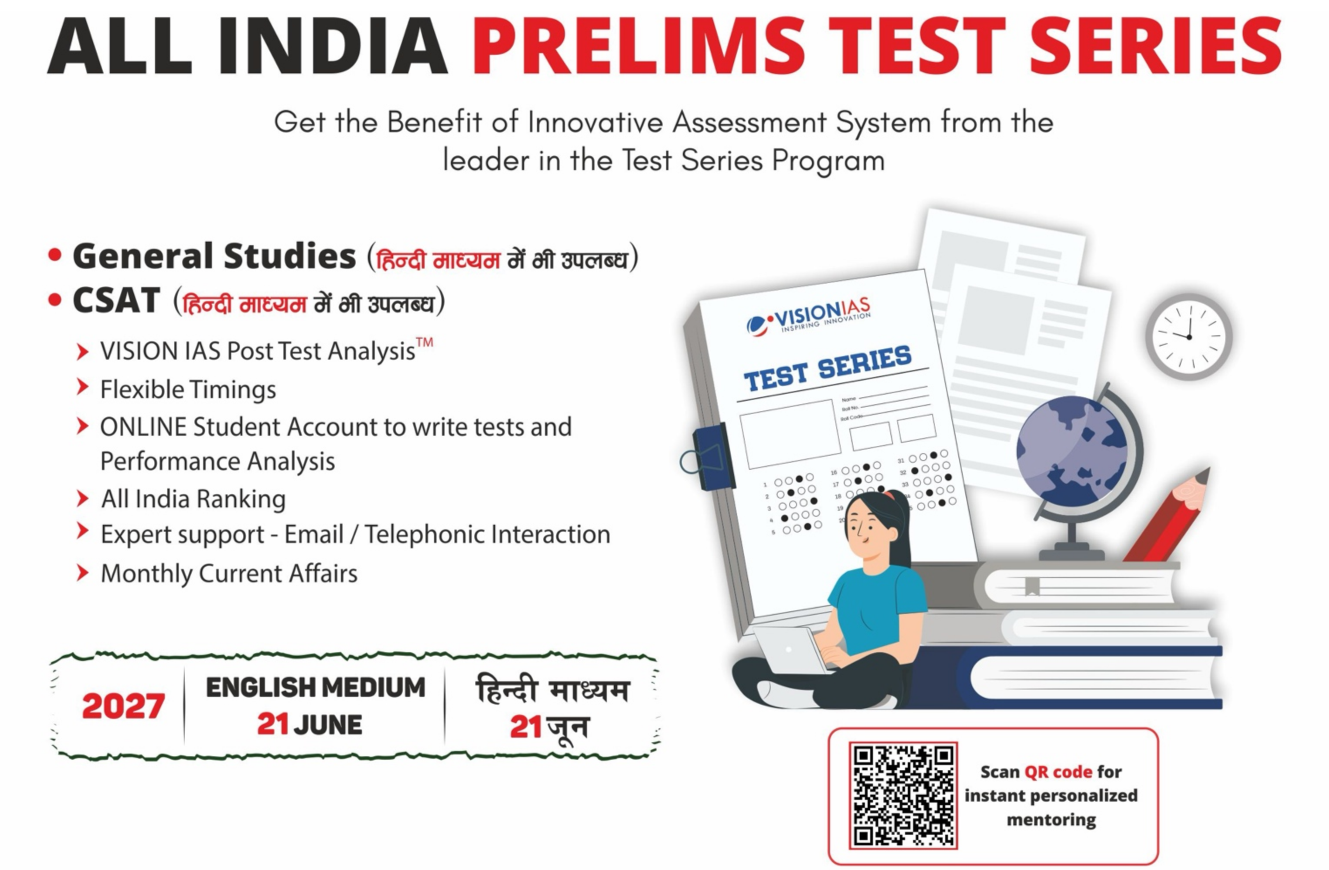
Environmental, Social, and Governance (ESG)	• **Definition:** Framework for evaluating a company's sustainability and ethical practices. • **Initiatives in India**: Business Responsibility and Sustainability Reporting (BRSR): Notified by SEBI for top 1000 listed companies; Corporate Social Responsibility etc.
Land Subsidence	• Witnessed in **Delhi (National Capital Territory, NCT), Mumbai, Kolkata, Bengaluru** and **Chennai** due to excessive groundwater extraction. • **Delhi** recording highest sinking rate of 51 mm annually.
Environmental Impact of Conflicts	• Global militaries contribute ~**5.5% of global greenhouse gas emissions.**
Environmental laws	• **M.C. Mehta v. Union of India (1986) case:** Principle of Absolute Liability and applied Doctrine of Public Trust to natural resources • **T.N. Godavarman Thirumulpad Case (1995):** Expanded the definition of forest land • **Vellore Citizens Welfare Forum Case (1996):** Precautionary Principle and the Polluter Pays Principle • **S.P. Muthuraman Case (2025)**: Declared post-facto or retrospective environmental clearances illegal
Renewable Energy and Alternative Energy Resources	
Renewable Energy (RE) in India	• **Key Targets:** o **60%** cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2035 (India's NDC). o 50 % of installed electric power capacity from non-fossil fuel sources by 2030; Reach **non-fossil energy capacity of 500 GW (Panchamrita targets for 2030)** • **Status:** o **NDC for 2030 Achieved in June 2025**: 50% of cumulative electric power installed capacity from non-fossil o **Capacity Addition:** 55.3 GW of non-fossil fuel during FY 2025-26. o Renewables met around **51.5% of India's total electricity demand**. o **India's Global Rank: 3rd RE producer** with an installed capacity of **250.52 GW.**
Energy Transition	• **Financing Gap: USD 6.5 trillion** by 2070 for Net zero. • **Challenges:** High storage cost (~₹5–6 per unit storage cost); Land acquisition (solar needs 300 times more space than nuclear).
Electric Mobility	• **India Electric Mobility Index (IEMI): First-of-its-kind** tool launched by NITI Aayog in partnership with World Resources Institute India. o For 2024, **Delhi** topped (score 77), followed by **Maharashtra** (68). • **EV penetration Status in India (NITI Aayog): 7.6%** EV penetration in 2024, below **30% target for 2030**. • **Initiatives:** PM E-DRIVE Scheme, Scheme to Promote Manufacturing of Electric Passenger Cars in India, National Electric Mobility Mission Plan (NEMMP) 2020 etc.
National Bioenergy Programme (NBP)	• **Components of NBP:** Waste to Energy Programme, Biomass Programme, Biogas Programme • **Status of Bioenergy in India** o **Total Installed capacity:** 11.6GW (Nov. 2025) o Modern bioenergy accounts for **13% of India's total final energy consumption.**

Ethanol Blending	• **Achievements:** ○ **E20 (20% Ethanol) target** achieved **in 2025** (5 years ahead of schedule). ○ **E85 rolled out** across several retail outlets of Public Sector OMCs. • **Key Developments:** ○ **Approved regulations for E100 fuel**. ○ **Central excise duty exemptions** to petrol blended with **22%, 25%, 27% and 30% ethanol** • **Initiatives:** Ethanol Blended Petrol (EBP) Programme, PM JIVAN, Ethanol Interest Subvention Schemes (EISS) etc.
Solar Energy in India	• **Present Capacity: 150.26 GW (Cumulative)** as on **31st March 2026.** • **Global Rank: 3rd** (IRENA Renewable Energy Statistics 2025). • **Updated National Solar Potential Assessment**: ~3,343 GWp (National Institute of Solar Energy (NISE)). • **Initiatives:** PM Surya Ghar (2024), Production-Linked Incentive (PLI) Scheme for Solar PV, PM-KUSUM etc.
International Solar Alliance (ISA)	• **Objective:** Towards **1000 strategy to unlock US$ 1 trillion in low-cost solar investment by 2030,** providing **clean energy access to 1 billion people, mitigate 1 billion tonnes of CO_2 emissions** annually. • **Initiatives under ISA:** OSOWOG; STAR-C initiative, etc. • **Achievements** ○ **Membership expanded to 125 countries**; India re-elected as President (2024-26). ○ Successful **institutionalization with focus on catalytic finance**, **capacity building** (STAR-C), and **innovation** (SolarX). ○ Operationalization of **Global Solar Facility** and **Viability Gap Funding** for LDCs & SIDS
Hydrogen Energy	• **Green Hydrogen**: Hydrogen produced through **electrolysis splitting water molecules** into hydrogen and oxygen using electricity from renewable sources like solar, wind etc. • **India's Target: 5 MMT per annum** of Green Hydrogen **by 2030**. (**National Green Hydrogen Mission)** • **Initiatives:** National Green Hydrogen Mission-**Strategic Interventions for Green Hydrogen Transition (SIGHT)** programme, Green Hydrogen Certification Scheme of India
Geothermal Energy	• **Definition:** Harnesses heat stored within the Earth's crust • **Estimated Potential in India:** 10,600 MW (Geothermal Atlas of India, 2022). • **Initiatives:** National Policy on Geothermal Energy (2025)
Coal Gasification	• **India's Target:** Gasify **100 Million Tonnes (MT)** of coal **by 2030. (National Coal Gasification Mission)** • **Initiatives:** Coal Gasification Incentive Scheme
Wind Energy	• **Global status: 4th largest wind power installed capacity.** • **Significant growth**: From **21.04 GW in 2014** to **56 GW (2026).** • **Initiatives:** National Wind-Solar Hybrid Policy, 2018, Viability Gap Funding (VGF) for offshore wind energy projects etc.
Conservation Efforts	
National Report by India on Convention on Biological Diversity	**India's Key Achievements in its 7th National Report under** Convention on Biological Diversity **(CBD)** • Forest carbon stock reached **7,285.5 million tonnes.** • **24.1 million hectares (mha) restored or under restoration.**

	• **100 Ramsar sites** as of Jun 2026 (26 in 2014). • **Protected Areas covers 5.71%** of land area
UN High Seas treaty	• International treaty under **United Nations Convention on the Law of the Sea (UNCLOS).** • **Key pillars:** Marine Protected Areas (MPAs); Marine Genetic Resources (MGRs); Capacity Building and Transfer of Marine Technology, etc.
Forest Conservation	• India's Targets: ○ **NDCs:** Create **carbon sink** through forest and tree cover to **3.5-4.0 billion tonnes of CO_2 equivalent** by 2035 from 2005 level. ○ **Bonn Challenge:** Restore 26 million hectares by 2030. • **India's Achievements:** ○ **Total forest & tree cover:** 25.17% of the geographical area (24.62% in 2021) (India State of Forest Report 2023) ○ **9th** in **total forest area globally.** (Global Forest Resource Assessment 2025).
Aravalli	• **Oldest residual fold mountain ranges** of world **(Pre-Cambrian).** • **North-western India; ~692 km** covering **Delhi, Haryana, Rajasthan, Gujarat.**
Biodiversity Governance	• **Legal Foundation:** Biological Diversity Act (BDA), 2002 • **Three-Tier Structure:** National Biodiversity Authority (NBA); State Biodiversity Boards (SBBs); Biodiversity Management Committees (BMCs**).**
Wildlife Conservation in India	• **Protected Areas** covers **5.71% of India's geographical area with 106 National Parks (As of December 2024)** • **Achievements:** Achieved targets set under TX2 initiative in 2018 (4 years in advance) • **Initiatives:** Project Tiger; Project Cheetah (2022); International Big Cat Alliance (IBCA), Integrated Development of Wildlife Habitats (IDWH) etc.
Human Wildlife Conflict	• 1630 people killed by animals (Accidental Deaths & Suicides in India 2024).
Wetland Conservation	• **Current Status in India: 7 lakh wetlands** covering **4.86%** of geographic area. • **Loss:** India **lost 2 out of 5 wetlands** in last 3 decades (Wetlands International). • **Initiatives:** Wetland (Conservation and Management) Rules 2017; Water Act, 1974; Environment Protection Act, 1986; National Programme for Conservation of Aquatic Ecosystems (NPCA), 2013 etc.
Coral Bleaching	• **4th mass coral bleaching event** announced by **NOAA in 2024.** • **Great Barrier Reef** (world's largest coral system) experienced biggest decline in four decades.
Genetic Resources and Associated Traditional Knowledge	• **Genetic Resources (GRs):** Resources contained in medicinal plants, agricultural crops, and animal breeds • **Traditional knowledge (TK):** Knowledge system held by indigenous communities • **Initiatives:** Traditional Knowledge Digital Library (TKDL); Patent Act, 1970; Protection of Plant Varieties and Farmer's Rights Act, 2001; Biological Diversity Act, 2002; Geographical Indications Act 1999, etc.
International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)	• **First Legally binding Treaty on Crop Genetic Diversity** to Conserve Crop Diversity; Sustainable Use of Genetic Resources and Fair and Equitable Benefit sharing. • **Digital Sequence Information (DSI):** No consensus on its exact definition under CBD, digital storage of genetic data derived from DNA, RNA, proteins or other biological sequences. ○ **Cali Fund for DSI:** Global benefit-sharing mechanism created at CBD COP-16.

Disaster Management	
Disaster Risk Reduction (DRR) Financing	• **Disaster Risk Reduction (DRR):** Steps taken to prevent new and reduce existing disaster risk and manage risk retention (aka residual risk), thereby strengthening resilience and sustainable development. • **India's DRR Financing** o **Measurement Tool:** Disaster Risk Index (DRI) o **Current Allocations** under **15th Finance Commission (FC)**: Exceeds **INR 2.32 trillion (~USD 28 billion).**
Localization of Disaster Risk Reduction (DRR)	• **National Project for Strengthening Community-Based DRR Initiatives in Panchayati Raj Institutions (PRIs)** o By **Ministry of Panchayati Raj (MoPR)** and **National Disaster Management Authority (NDMA)**. o **Cluster-Based Model: 20** Gram Panchayats (GPs) in **each district** will be covered. • **Best Practices:** o **Ecosystem-based DRR** undertook during restoration of Tampara Wetland (Odisha) o Hazard risk mapping, Formation of village-level disaster response teams, Emergency Operations Centre (EOC) for disaster coordination etc. done by **Pozhuthana Panchayat, Kerala** during 2018 Kerala floods.
Urban Resilience	• India's urban population projected to **increase from 480 million in 2020 to 951 million by 2050 (World Bank).** • Storm water flooding risk to **rise to 3.6 to 7 times by 2070.** • **Urban Heat Island (UHI) effect Causes Economic output loss** e.g. Chennai could lose 3.2% of its GDP by 2050. • **Initiatives:** Climate Smart Cities Assessment Framework (CSCAF), C-FLOOD, AMRUT etc.
Coastal Regions	• **Economic:** E.g., Cyclone Fani caused ~**US$1.2 billion power infrastructure damages** in Odisha (2019). (Global Assessment Report (GAR), 2025) • **Threat to Ecosystems and biodiversity,** e.g., Half of world's mangroves could **face severe risks by 2100**. **(**Risk index for mangroves). • **Initiatives:** Coastal Regulation Zone (CRZ) Notification (2019) ,Coastal Vulnerability Index (CVI), Coastal Management Information System (CMIS), etc.
Maritime Disasters	• **Examples:** Sinking of Liberian-flagged vessel MSC ELSA 3 (Kochi coast); Fire aboard MV Wan Hai 503 (Kerala Coast), etc. • **Initiatives:** o **Global:** Convention on International Trade in Dangerous Goods at Sea (IMDG Convention), International Convention for the Safety of Life at Sea (SOLAS), 1974 etc. o **India:** Merchant Shipping Act, 1958, National Oil Spill Disaster Contingency Plan, National Maritime Search And Rescue Plan – 2022 etc.
Crowd Disaster Management	• **Examples:** Andhra Pradesh's Venkateswara Swamy Temple, Bengaluru (RCB's IPL celebration), etc. • **Stampedes in India**: Nearly **4,000 stampede events** were recorded in last 3 decades. majority in religious sites.
Dam Safety	• India is **3rd largest dam-owning nation** after China and USA. • **6,628 specified dams** in India **(Maharashtra** has highest number). • **Ageing:** About 26% dams in India are more than 50 years old. • E.g., 2023, Chungthang Dam (Sikkim).

Glacial Lake Outburst Floods (GLOFs)	• **Status:** > 31,000 glacial lakes growing across High Mountain Asia (HMA). [IIT Roorkee]. ○ Out of **100 glacial lakes** over **10 hectares in size**, an **increasing trend in water spread** area in **34 (CWC).** • E.g. South Lhonak, Sikkim (2023).
Fire Safety	• **Status:** 5,888 fire-related deaths recorded nationally in 2024. (NCRB report) • Fire services are **State subject** falling under 12th Schedule (Article 243W), assigning responsibility to Urban Local Bodies. • E.g., **Cuttack hospital fire (2026),** North Goa's Night Club Fire (2026) etc.
Extreme Heat	• Majority of Indian population **faces high to very high risk** (Council on Energy, Environment (CEEW) assessment of **heat risk across 734 districts in India**) • North India's humidity rose from **30-40% (1982-2011)** to **40-50% (2012-22)** limiting body's cooling through sweat.
Geography	
Bharat Forecast System	• **Developed by** Indian Institute of Tropical Meteorology (IITM), Pune. • **Role:** Enhances **India's weather prediction resolution from 12 km to 6 km**.
Pacific Ring of Fire	• **Accounts for: ~75% of world's active** volcanoes; **~90% of world's** earthquakes.
Super El Nino	• Exceptionally **strong El Niño event** where **sea surface temperatures in central and eastern equatorial Pacific rise by more than 2°C** above normal for a sustained period.



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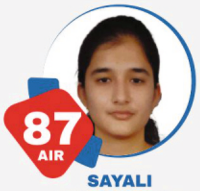

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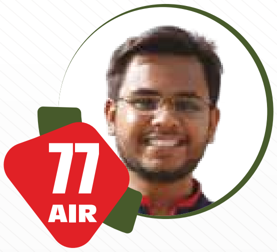

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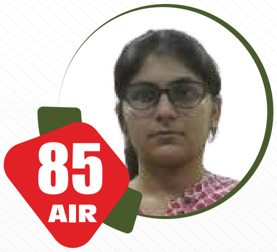

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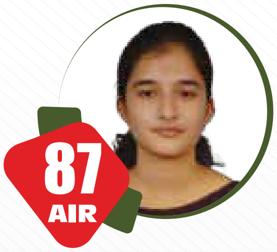

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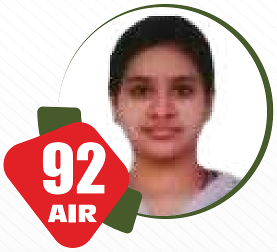

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